New pigments of *Cortinarius* Fr. and *Dermocybe* (Fr.) Wünsche (Agaricales) from Australia and New Zealand*

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Gill, M. (1995). New pigments of *Cortinarius* Fr. and *Dermocybe* (Fr.) Wünsche (Agaricales) from Australia and New Zealand. – Beih. Sydowia X: 73–87.

The chemical structures and interrelationships of pigments from fruit-bodies of several *Dermocybe* and one *Cortinarius*, subgenus *Myxacium*, indigenous to Australasia are described. Most of the pigments are new and some chemotaxonomic inferences are drawn from biogenetic relationships.

Keywords: Agaricales, chemotaxonomy.

The present taxonomic structure of *Dermocybe* (Fr.) Wünsche and various sect. of *Cortinarius* Fr. is strongly influenced by chemotaxonomic data (Moser, 1985; Moser in Singer, 1986), particularly important being pigments present in the fruit-bodies (Gill & Steglich, 1987). Most of the pigments isolated hitherto from *Dermocybe* and *Cortinarius* in Europe are either anthraquinones or molecules that bear a close structural and biogenetic relationship to them (Gill & Steglich, 1987). In view of the relevance of these substances to taxonomy and the relative ease with which they can be extracted and analysed by thin-layer chromatography (Kidd & al., 1985), chemotaxonomic studies on European species of *Dermocybe* and *Cortinarius* by Moser (1972), Høiland (1980; 1983), Keller (1982), Moser & Keller-Dilitz (1983), and by Steglich & Oertel (1984) have proved most valuable. Similarly, the pigments of South American species of *Dermocybe* and *Cortinarius* have been studied using paper chromatography by Gruber (1975) and more recently thin-layer chromatography by Keller & al. (1987). Keller & Ammirati (1983) have reported on the pigmentation of North American *Dermocybe* taxa. In most previous studies, specific pigment combinations can be recognized that can be conveniently applied to the differentiation of infrageneric taxa and to the reinforcement of groupings made on the basis of other micro- and macroscopic criteria.

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* Pigments of Fungi, Part 33; for Part 32 see Cotterill & Gill (1993). This paper is dedicated to Professor M. Moser on the occasion of his seventieth birthday.

To date, very little has been known about the chemical structure and properties of the pigments in any of the Australasian taxa. However, some progress has been made on the chemistry (Gill, 1994) and mycology of Australasian taxa (Horak, 1983; 1987; Keller & al., 1987; Grgurinovic, 1989; Horak & Wood, 1990; Høiland & Watling, 1990) and this has made it apparent that new features and phenomena are operating and that these facts require diagnosis and analysis from a standpoint completely different from that applied in the Northern Hemisphere.

In recent works by Horak (1987) and Keller & al. (1987) pigment profiles are presented for all known *Dermocybe* taxa in New Zealand and Papua New Guinea and mention is made of some of those that occur in Australia. It is apparent, even from this comparatively small survey, that *Dermocybe* species from the Southern Hemisphere are exceptionally diverse as indicated by a multitude of pigment types. Most significant from the taxonomic viewpoint is (a) the realisation that many of these pigments are different from those associated with the Northern Hemisphere taxa, (b) that they are often limited in their distribution to a small number of species or even to a single species, and (c), that most of the chemical structures are rare or hitherto unknown.

In this paper the structures of several unique pigments that have been isolated from Australian and New Zealand *Dermocybe* and *Cortinarius* taxa are reported and some taxonomic inferences are drawn.

Material and methods

Fungal material included in this study is listed in Tab. 1 along with geographic origin and accession number under which voucher specimens are held in the Herbarium of the Royal Botanic Garden, Edinburgh.

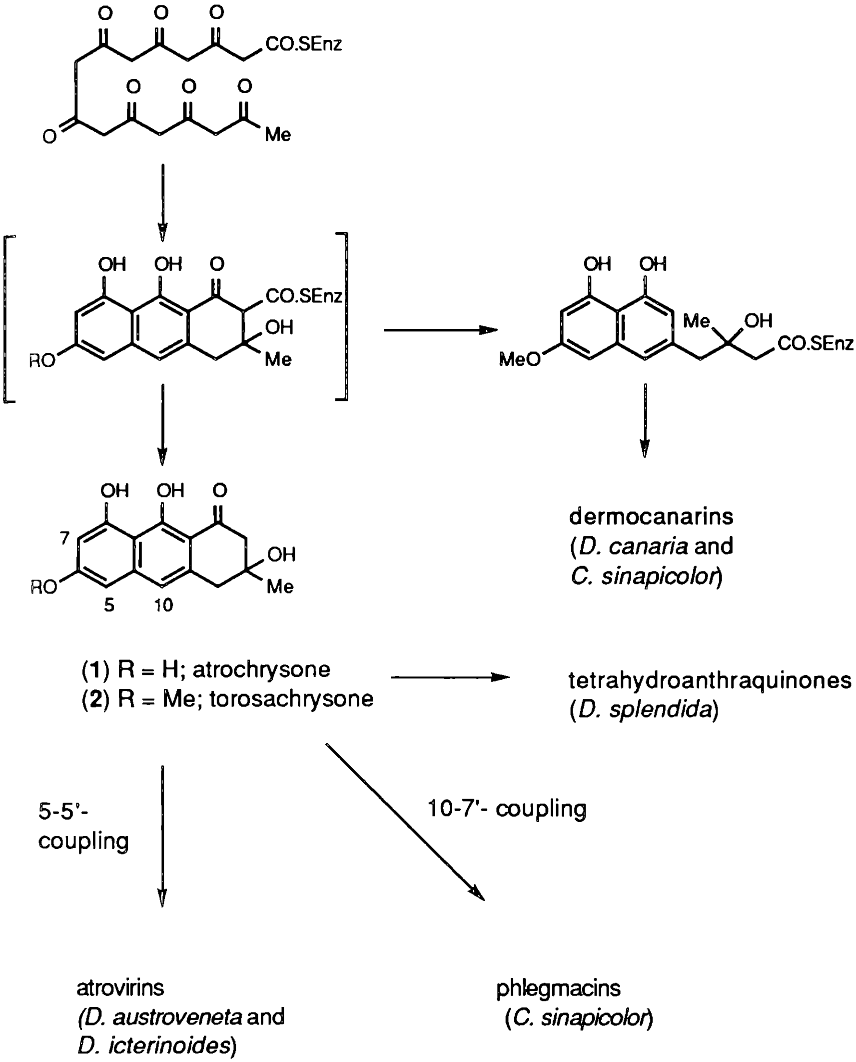
Tab. 1. – New pigments of *Dermocybe* and *Cortinarius*: list of species examined. Abbreviations: AUS = Australia; NZ = New Zealand; E Herbarium of Royal Botanic Garden, Edinburgh, Scotland.

Species	Herbarium, Nr.	Origin
Dermocybe splendida Horak	E, WAT. 18086	AUS
D. austroveneta (Cleland) Moser & Horak	E, WAT. 19344	AUS
D. icterinoides Horak	E, WAT. 24300	NZ
D. canaria Horak	†	AUS
D. canaria	E, WAT. 22915	NZ
Cortinarius sinapicolor Cleland	E, WAT. 24272	AUS
Dermocybe cardinalis Horak	E, WAT. 22916	NZ

† Identity confirmed by comparison with type material (E. Horak, personal communication to W. Steglich).

Extraction and purification of pigments

Pigments were isolated from fresh or deep-frozen carpophores by maceration in ethanol. An exception applies to the extraction of *Dermocybe austroveneta*, which is discussed separately in the text. Extracts were routinely purified by preparative thin-layer chromatography on glass plates coated with a layer of silica gel (Merck Kieselgel GF_{254}, 20 × 20 × 0.1 cm) using toluene : ethyl formate : formic acid 50 : 49 : 1 as eluant.



Scheme 1. – Biogenetic role of dihydroanthracenones.

Identification of pigments

Pigments were identified by detailed analysis of the mass, infrared, ultraviolet, ^{13}C and ^{1}H-NMR spectra, including two-dimensional ^{1}H-^{1}H and ^{1}H-^{13}C correlation shift experiments.

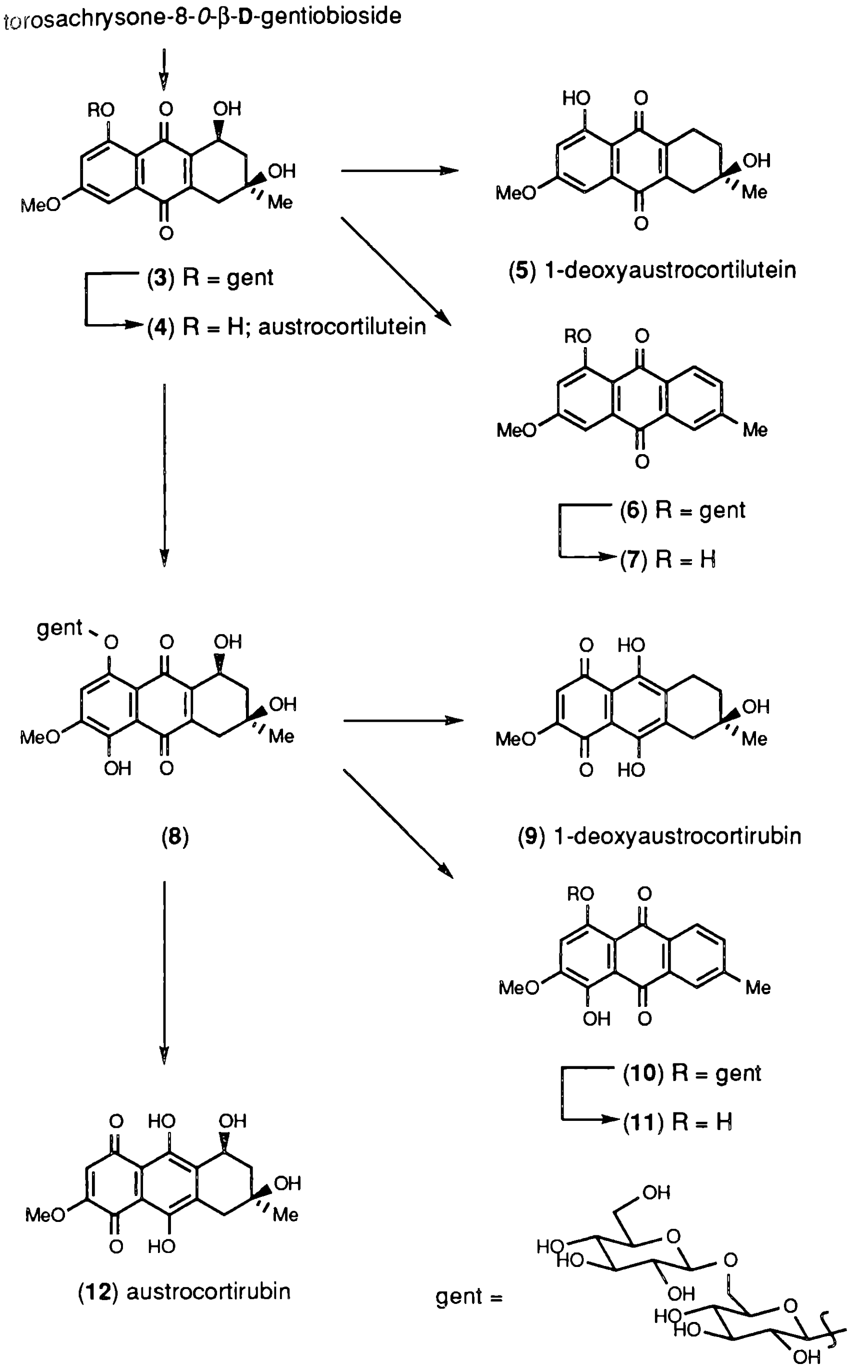
Results and discussion

The majority of pigments isolated to date from *Dermocybe* and *Cortinarius* are derived biogenetically from so-called octaketide progenitors via dihydroanthracenones of the atrochrysone (**1**) and torosachrysone (**2**) types (Scheme 1) (Gill & Steglich, 1987; Gill & al., 1989; 1992). This pathway also operates in *Dermocybe splendida* (Gill & al., 1990), *D. austroveneta* (Gill & al., 1988; Gill & Gimenez, 1991), *D. icterinoides*, *D. canaria* (Keller & Steglich, 1987; Gill & Gimenez, 1990a), and in *Cortinarius sinapicolor*, but pigment biosynthesis in *Dermocybe cardinalis* takes a different route.

Dermocybe splendida

Dermocybe splendida from New Zealand (Horak, 1983; 1987) was first examined chromatographically by Keller (1979) who was unable to identify any of the red and yellow pigments with anthraquinones known at that time. Later, Keller & al. (1987) were able to name six of the pigments by direct comparison with purified materials isolated from Australian specimens and supplied by our laboratories (Gill & Strauch, 1985; Archard & al., 1985; Gill & Smrdel, 1987; Gill & al., 1990). The principal yellow and red pigments isolated from the ethanol extracts of *D. splendida* are the tetrahydroanthraquinones austrocortilutein (**4**) and austrocortirubin (**12**), the former occurring in two stereoisomeric forms (Gill & al., 1990). Minor pigments are the 1-deoxy derivatives (**5**) and (**9**) of the major pigments (Gill & Smrdel, 1987), the anthraquinones (**7**) and (**11**) that are derived from the major pigments by loss of water (Archard & al., 1985), and finally torosachrysone (**2**) (Gill & al., 1989), which, as its 8-*O*-β-**D**-gentiobioside is the natural progenitor of all other pigments in this fungus. Interrelationships between the pigments of *D. splendida* are shown in Scheme 2. Tetrahydroanthraquinones of the types (**4**) and (**12**) were known previously only from parasitic conidial fungi such as *Alternaria solani* and *Bostrychonema alpestre*, the causal agents of blight disease of potato and water hyacinth, respectively (Thomson, 1987).

In the intact fruit-bodies of *D. splendida* the quinones (**4**), (**7**), (**11**), and (**12**) are present largely as their 8-*O*-β-**D**-gentiobiosides (**3**), (**6**), (**10**), and (**8**), respectively, from which they arise naturally by



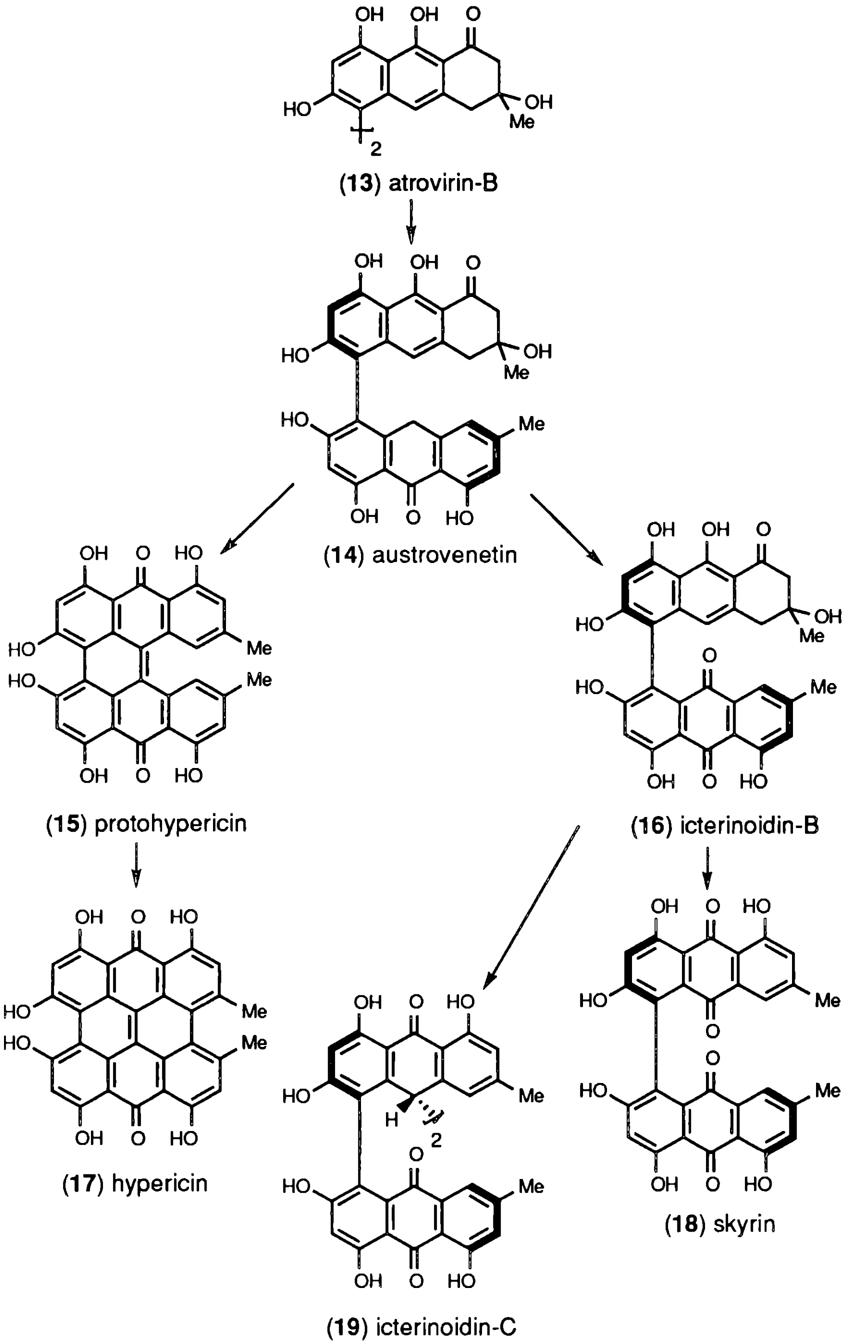
Scheme 2. – Biogenetic relationships between pigments of *D. splendida*.

glycolysis or during the course of the extraction and purification procedure. The gentiobiose residue in the pigments (**3**) and (**8**) is particularly labile being completely cleaved during twelve hours in ethanolic solution. Furthermore, the tetrahydroanthraquinones (**4**) and (**12**) are themselves prone to dehydration to afford the anthraquinones (**7**) and (**11**) if care is not taken to minimize their exposure to acid. Consequently, deliberate exposure of *D. splendida* extracts to acid (Keller & al., 1987) significantly alters the pigment profile compared to that which exists in the intact organism.

Examples from *Cortinarius* and *Dermocybe* in which pigments are present as sugar derivatives are extremely rare (Gill & Steglich, 1987). The gentiobiose residue has never been reported before in this context.

D. splendida has been related to the taxonomically yet doubtful (Moser & Horak, 1975) Australian taxon *Cortinarius umbonatus* (Cleland & Harris, 1948) by the presence of the quinones (**4**), (**5**), (**7**), (**9**), (**11**), and (**12**) (Keller & al., 1987). We have found red pigments of the austrocortirubin type in only two other Australian species. The first, *Dermocybe erythrocephala* (Dennis) Moser, is a blood-red toadstool collected by J. E. C. Aberdeen in Queensland and first placed in *Cortinarius* by Dennis (1955). It was later suggested by Moser (1972) that *D. erythrocephala* is synonymous with *D. sanguinea* (*sensu* Cleland, 1934) but our chemical work on the latter taxon (Gill & Gimenez, 1990b) coupled with the observations reported herein clearly establish that this can not be the case. Thus, extraction of a dried specimen of the type collection of *D. erythrocephala* provided on loan from the Plant Pathology Branch of the Department of Primary Industries, Queensland (BRIP), gave the red quinones (**9**), (**11**), and (**12**), but no trace of the yellow quinones (**4**) and (**5**) (Gimenez, 1990). The second is an incompletely described taxon in which the red pigments (**9**), (**11**), and (**12**) are restricted to a flame-red tip at the base of the stipe (*Cortinarius basirubescens*?; Keller, 1979). Other parts of the carpophore are yellow-brown and owe their pigmentation to the quinones (**4**), (**5**), and (**7**) (Gill & Yu, unpublished).

In contrast, austrocortilutein (**4**) and the related yellow pigments (**5**) and (**7**) have been isolated by us in various stereochemical forms from five as yet undescribed *Dermocybe* taxa (Gill & al., 1992) in which the red quinones, e.g. (**12**), are absent. It is suggested that these unnamed species, together with *D. splendida*, *D. erythrocephala* and *Cortinarius umbonatus* form a new group in which tetrahydroanthraquinones are the major pigments that are otherwise without affinities to other known taxa.



Scheme 3. – Biogenetic relationships between pigments of *D. austroveneta* and *D. icterinoides*.

Dermocybe austroveneta and *D icterinoides*

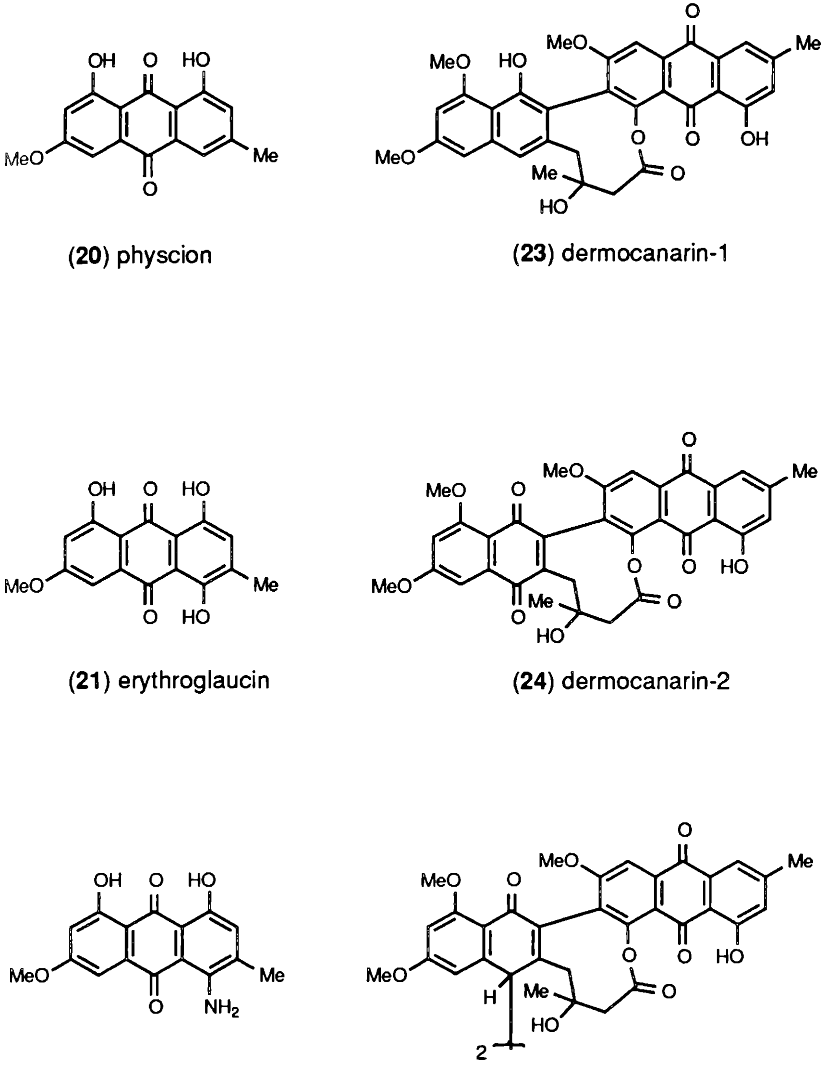
Dermocybe austroveneta (Cleland) Moser is placed in the sect. *Pauperae* of the subgen. *Icterinula* by Moser (1986). Chromatographic analysis by Keller & al. (1987) of several South American taxa belonging to sect. *Pauperae*, and including two New Zealand taxa, namely *D. alienata* Horak and *D. icterinoides* Horak, revealed that the two major pigments present in the ethanolic extracts of fungi of this group are the purple extended quinone hypercin (**17**) and the orange anthraquinone skyrin (**18**).

We have carefully examined the acetone extractives from fresh fruit-bodies of *D. austroveneta* and found that when these are obtained and processed in the absence of air and light the principal pigments are skyrin (**18**) and the green-yellow pre-anthraquinone, austrovenetin (**14**) (Gill & al., 1988; Gill & Gimenez, 1991). Austrovenetin (**14**) is extremely unstable to oxygen in the presence of which it is rapidly transformed to the violet pigment protohypericin (**15**). In turn, protohypericin (**15**) on exposure to sunlight is immediately converted to the final product, hypericin (**17**). As far as *D. austroveneta* is concerned, we are confident that the violet and purple pigments (**15**) and (**17**) are not present in fresh, undamaged carpophores but are instead artefacts of the extraction and purification procedure. The same could well apply to those taxa described by Keller & al. (1987) in which hypericin (**17**) is conspicuous in chromatograms by its colour and cherry red fluorescence under ultraviolet light.

Interestingly, when fruit-bodies of *D. austroveneta* become decayed and/or damaged by larval attack they develop violet-purple bruises that are no doubt due to the accumulation of hypericin (**17**) that arises by chemical modification of austrovenetin (**14**).

We have also studied the pigments of *D. icterinoides*, one of the New Zealand taxa examined by Keller & al. (1987). From ethanolic extracts we have isolated the known pigments atrovirin-B (**13**) and skyrin (**18**), and the new quinones icterinoidin-B (**16**), its atropisomer icterinoidin-A (not shown) and the curious tetramer, icterinoidin-C (**19**) (Gill & Morgan, unpublished). The presence of hypericin (**17**) is clear from the thin-layer chromatograms, it probably arises during extraction and purification from austrovenetin (**14**) present in the intact carpophores.

The pigments of *D. austroveneta* and *D. icterinoides* fall logically into the biogenetic pattern shown in Scheme 3. Chemically they have affinities, either actual or artefactual, not only to other members of the sect. *Pauperae* of subgen. *Icterinula* but also to subsect. *Atrovirentes* of sect. *Scauri* Fr. of subgen. *Phlegmacium* which is characterized by the presence of atrovirin-B (**13**), skyrin (**18**), and



(**20**) physcion

(**23**) dermocanarin-1

(**21**) erythroglaucin

(**24**) dermocanarin-2

(**22**) 4-aminophyscion

(**25**) dermocanarin-3

Scheme 4. – Pigments of *D. canaria*.

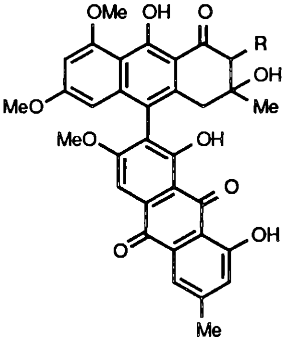
probably hypericin (**17**) (Steglich & Oertel, 1984). Our results provide further support to the suggestion by Keller & al. (1987) that sect. *Pauperae* of subgen. *Icterinula* should be grouped with subsect. *Atrovirentes* of sect. *Scauri*.

Dermocybe canaria and *Cortinarius sinapicolor*

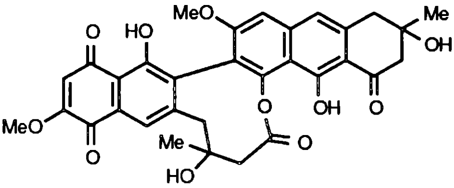
Dermocybe canaria Horak, a common species in New Zealand *Nothofagus* forests, occupies an isolated taxonomic position within the infragenic frame of *Dermocybe*. Keller & Steglich (1987) have shown that the brilliant yellow colour of the fruit-bodies is due to large quantities of physcion (**20**) together with lesser amounts of the related anthraquinones (**21**) and (**22**). Our own work with specimens collected both in New Zealand and Tasmania has confirmed the presence of the quinones (**20**) and (**21**) and further established that these pigments are present to a significant extent as their 1-*O*-*β*-**D**-glucopyranosides (Gimenez, 1990). Studies on the intensely yellow mycelial mat (Gill & Gimenez, 1990a) led to the discovery of the first three members of a completely new class of coupled anthraquinonoid pigments, the so-called dermocanarins (Scheme 4). The two halves of the dermocanarin molecule, that is the anthracene moiety on one hand and the naphthalene ring together with the lactone bridge on the other, are formed independently from two molecules of a precursor of the torosachrysone (**2**) type. At some stage in the biogenesis these units are joined by an ester linkage and a biaryl bond to ultimately afford pigments such as the dermocanarins-1 (**23**) and -2 (**24**). Dermocanarin-3 (**25**), a complex tetramer, is formed by coupling together of two molecules of dermocanarin-1 (Gimenez, 1990). The dermocanarins-1, 2, and 3 are present in the carpophores of *D. canaria* only in trace proportions compared to the quinones (**20**) and (**21**) and their glucosides. The presence of physcion (**20**) as the most abundant pigment and the occurrence of the dermocanarins, hitherto found in no other *Dermocybe* taxon, supports the isolated taxonomic position proposed for *D. canaria*.

To date we have found pigments of the dermocanarin class in five other Australian taxa. Of these only one, *Cortinarius sinapicolor* Cleland, has been fully documented. The bright mustard yellow coloured basidiomes of *C. sinapicolor* have been beautifully illustrated (but erroneously identified as '*C. ochraceus*') by Cole & al. (1984) and Fuhrer (1985). It is placed in sect. *Pyromyxae* of subgen. *Myxacium* by Moser (1986), a placement supported by Grgurinovic (1989). Its taxonomic position and relationship with the confused '*C. ochraceus*' have recently been discussed by Horak & Wood (1990).

The pigments of *C. sinapicolor* are shown in Scheme 5. They fall into two different chemical groups, each one providing chemotaxonomic links with apparently diverse subgenera within the *Cortinarius* -*Dermocybe* framework. The most abundant yellow pigment is the new hydroxyphlegmacinquinone (**26**), which is accompanied by a minor quantity of the known phlegmacin derivative (**27**) (Gimenez, 1990; Gill & Milanovic, unpublished). A phlegma-



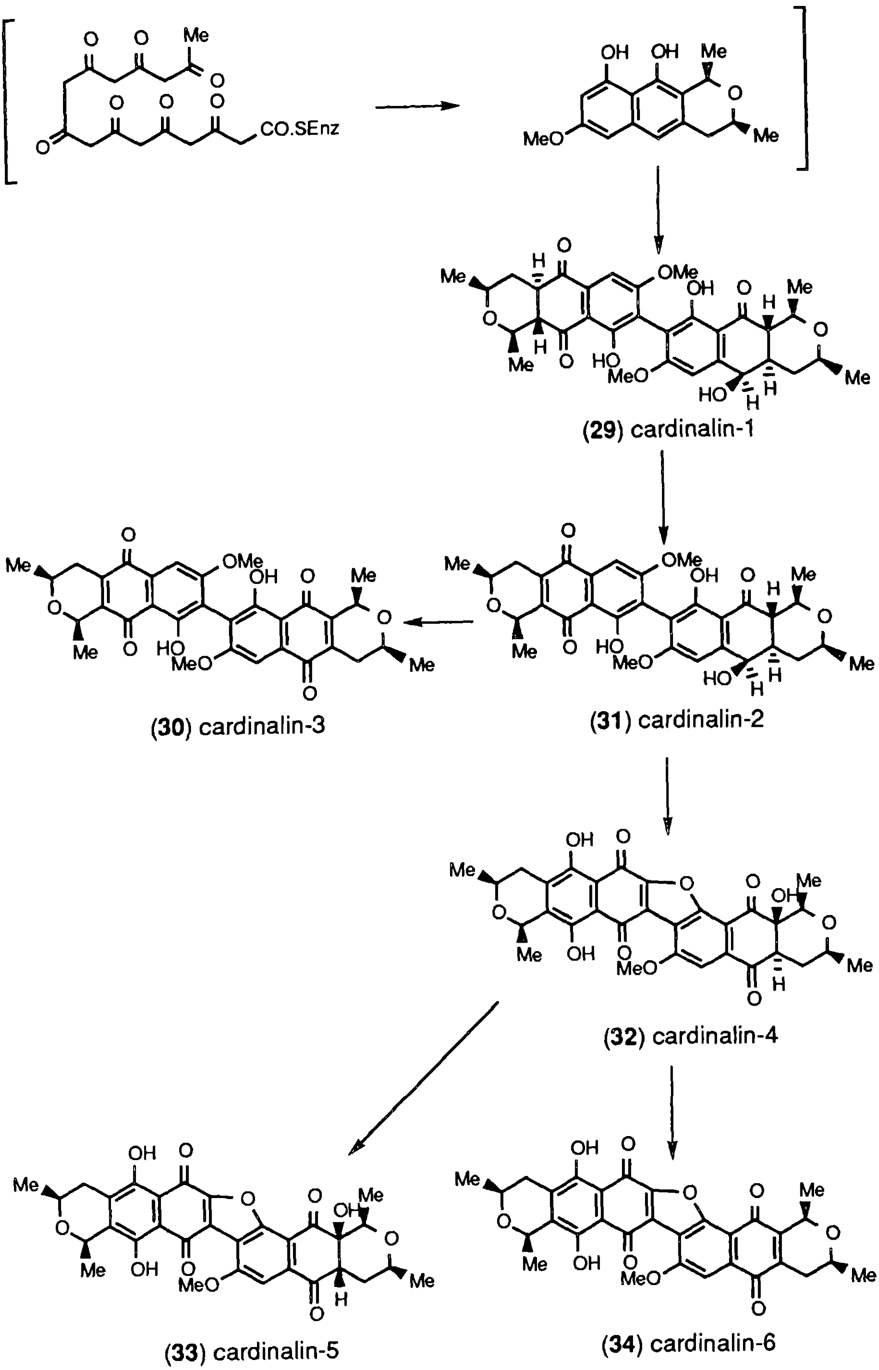
(26) R = OH
(27) R = H



(28) dermocanarin-4

Scheme 5. – Pigments of *Cortinarius sinapicolor*.

cinquinone with the same structure and chiroptical properties as the minor pigment (**27**) from *C. sinapicolor* has been described previously from *C. percomis*, *C. nanceiensis*, and *C. russeoides*, members of the subsect. *Percomes* of sect. *Scauri* (*Phlegmacium*) (Steglich & Oertel, 1984), where it and similar pigments are regarded as important taxonomic markers (Gill & Steglich, 1987). The occurrence of the phlegmacinquinones (**26**) and (**27**) in *C. sinapicolor* may reveal affinities to sect. *Scauri*, which has already been linked with sect. *Pauperae* of subgen. *Icterinula* by Keller & al. (1987). A link from *C. sinapicolor* to subgen. *Icterinula* of *Dermocybe* is further supported by our characterisation of dermocanarin-4 (**28**) as the second most abundant constituent of the mustard yellow *C. sinapicolor*. In the anthracene portion of dermocanarin-4 the ring system is at a torosachrysone level of development, less advanced than in the dermocanarins-1, 2 and 3 from *Dermocybe canaria*, while the naphthalene ring is oxidized to a naphthoquinone. If the dermocanarins are to be taken as a guide, then



(29) cardinalin-1

(30) cardinalin-3

(31) cardinalin-2

(32) cardinalin-4

(33) cardinalin-5

(34) cardinalin-6

Scheme 6. – Biogenetic relationships between pigments of *D. cardinalis*.

C. sinapicolor has systematic affinities rather to *Dermocybe* subgen. *Icterinula* than *Cortinarius* subgen. *Myxacium*, as is proposed by Horak & Wood (1990).

Dermocybe cardinalis

In New Zealand forests *D. cardinalis* represents one of the visually most striking species of *Dermocybe*. Ethanolic extracts of the type collection have been examined chromatographically by Keller & al. (1987) who concluded that the pigments, which range from yellow to purple, are unique to this species and at that time mainly unidentified. Nevertheless, it was speculated, wrongly as it turned out, that the major pigments of *D. cardinalis* are anthraquinones.

In fact, as the structures collected and interrelated in Scheme 6 reveal, the principal yellow, red, and purple pigments of *D. cardinalis* constitute a series of unique naphthoquinone dimers that we have elected to call, collectively, the cardinalins. Cardinalins 2-6 belong to the group of so-called benzoisochromanquinones that have hitherto been restricted in their distribution to various molds, plants, and soil microorganisms (Thomson, 1987). Cardinalin-1 (**29**) is colourless since the quinone chromophore is incompletely developed, nevertheless, it may be readily identified as a putative precursor to the remaining five pigments (**30**)–(**34**). The benzoisochroman ring system in its simplest (and as yet hypothetical) form prior to biaryl coupling is depicted at the top of Scheme 6. It may be seen to arise by way of an octaketide precursor (shown alongside) that is folded according to a pattern that is fundamentally different to that which operates in the vast majority of other *Dermocybe* taxa (cf. Scheme 1). The fact that benzoisochromanquinones have never before been isolated from Basidiomycotina attests to the unique, isolated position that is currently accorded to *D. cardinalis*.

Acknowledgments

Our work is generously supported by the Australian Research Council. I owe a considerable debt to the coworkers who are named in the references. Roy Watling (Royal Botanic Garden, Edinburgh) is thanked for lodging herbarium specimens and for help with identification. Tom May (National Herbarium of Victoria, Melbourne) has been a source of help and enthusiasm since our work commenced in 1984. The National Parks and Wildlife Division of the Department of Conservation, Forests and Lands kindly allow us to collect fungi in parks under their jurisdiction. The New Zealand species were collected and extracted during study leave at the Department of Chemistry, University of Canterbury, Christchurch.

References

Archard, M., M. Gill & R. J. Strauch (1985). New anthraquinones from the genus *Cortinarius*. – Phytochemistry 24: 2755–2758.

Cleland, J. B. (1933). Australian fungi: notes and descriptions. No. 9. – Trans. R. Soc. S. Austr. 57: 187–194.

— & J. R. Harris (1948). *Agaricus* and *Cortinarius* with special reference to antibiotic species (Illustrations and descriptions of South Australian fungi). 1. – Rep. South Aust. Museum 9: 43–56.

Cole, M., B. Fuhrer & A. Holland (1984). A field guide to the common genera of gilled fungi in Australia. (rev. ed.). – Inkata Press Pty. Ltd., Melbourne, Sydney, London, 11 pp.

Cotterill, A. S. & M. Gill (1993). Synthesis of *(S)*–(–)–austrocorticin and *(S)*–(+)–dermolactone: absolute stereochemistry of the natural products. Tetrahedron Lett. 34: 3155–3158.

Dennis, R. W. G. (1955). New or interesting Queensland Agaricales. – Kew Bull. 1955: 107–110.

Fuhrer, B. (1985). A field companion to Australian fungi. – Kyodo Printing Co. Ltd., Singapore, 62 pp.

Gill, M. (1994). Pigments of fungi (macromycetes). – Nat. Prod. Reports 11: 67–90.

— & A. Gimenez (1990a). The dermocanarins, unique macrocyclic lactones from the fungus *Dermocybe canaria*. – Tetrahedron Lett. 31: 3505–3508.

— & — (1990b). Pigments of fungi. 17. *(S)*–(+)–Dermochrysone, (+)–dermolactone, dermoquinone, and related pigments; new nonaketides from the fungus *Dermocybe sanguinea* (*sensu* Cleland). – J. Chem. Soc., Perkin Trans. 1: 2585–2591.

— & — (1991). Austrovenetin, the principal pigment of the toadstool *Dermocybe austroveneta*. – Phytochemistry 30: 951–955.

—, —, A. G. Jhingran & A. F. Smrdel (1989). Dihydroanthracenones from *Dermocybe splendida* and related fungi. – Phytochemistry 28: 2647–2650.

—, —, A. G. Jhingran & A. Qureshi (1992). New austrocortilutein stereoisomers from Australian fungi of the genus *Cortinarius*. Phytochemistry 31: 947–951.

—, — & R. W. McKenzie (1988). Pigments of fungi. 8. Bianthraquinones from *Dermocybe austroveneta*. – J. Nat. Prods 51: 1251–1256.

—, —, S. Saubern & A. F. Smrdel (1992). Tetrahydroanthraquinone and anthraquinone gentiobiosides from *Dermocybe splendida*; the first anthraquinonoid disaccharides from Basidiomycetes. – Nat. Prod. Lett. 1: 187–192.

—, — & R. Watling (1992). Pigments of fungi. 26. Incorporation of sodium [1,2–$^{13}C_2$]acetate into torosachrysone by toadstools of the genus *Dermocybe*. – J. Nat. Prods. 55: 372–375.

— & A.F Smrdel (1987). Deoxyaustrocortirubin and deoxyaustrocortilutein, tetrahydroanthraquinones from the genus *Cortinarius*. – Phytochemistry 26: 2999–3001.

—, —, R. J. Strauch & M. J. Begley (1990). Pigments of fungi. 12. Structure and absolute stereochemistry of antibiotic tetrahydroanthraquinones from the fungus *Dermocybe splendida* Horak; x–ray structure determination of austrocortirubin phenylboronate and austrocortilutein acetonide. – J. Chem. Soc., Perkin Trans. 1: 1583–1592.

— & W. Steglich (1987). Pigments of fungi (macromycetes). – Progr. Chem. Org. Nat. Products 51: 1–317.

— & R. J. Strauch (1985). New tetrahydroanthraquinones from the genus *Cortinarius*. – Tetrahedron Lett. 26: 2593–2596.

Gimenez, A. (1990). Studies on the constituents of the genus *Cortinarius*. – Ph. D. thesis, Univ. Melbourne.

Grgurinovic, C.A. (1989). Studies of J. B. Cleland's fungal herbarium. 2. *Cortinarius* subgenus *Myxacium* (Cortinariales). – Mycotaxon 36: 47–61.

Gruber, I. (1975). Papierchromatographische Pigmentanalyse von südamerikanischen Dermocyben und Cortinarien. – In: Moser, M. & E. Horak (eds). *Cortinarius* Fr. und nahe verwandte Gattungen in Südamerika. Beihefte zur Nova Hedwigia 52: 524–540.

Høiland, K. (1980). *Cortinarius* subgenus *Leprocybe* in Norway. – Norw. J. Bot. 27: 101–126.

— (1983). *Cortinarius* subgen. *Dermocybe*. – Opera Botanica 71: 1–112.

— & R. Watling (1990). Some *Cortinarius* spp. (*Agaricales)* of the Cooloola sand-mass, Queensland, Australia. – Pl. Syst. Evol. 171: 135–146.

Horak, E. (1983). Mycogeography in the South Pacific region: Agaricales, Boletales. – Aust. J. Bot. Suppl. Ser. 10: 1–41.

— (1987). New species of *Dermocybe* (Agaricales) from New Zealand. – Sydowia 40: 81–112.

— & A. E. Wood (1990). *Cortinarius* Fr. (Agaricales) in Australia. 1. Subgen. *Myxacium* and subgen. *Paramyxacium*. – Sydowia 42: 88–168.

Keller, G. (1979). Chemotaxonomische Pigmentuntersuchungen in der Gattung *Dermocybe* (Fr.) Wünsche. – Dissertation, Univ. Innsbruck.

— (1982). Pigmentationsuntersuchungen bei europäischen Arten aus der Gattung *Dermocybe* (Fr.) Wünsche. – Sydowia 35: 110–126.

— & J. F Ammirati (1983). Chemotaxonomic significance of anthraquinone derivatives in North American species of *Dermocybe*, sect. *Sanguineae*. – Mycotaxon 18: 357–377.

—, M. Moser, E. Horak & W. Steglich. (1987). Chemotaxonomic investigation of species of *Dermocybe* (Fr.) Wünsche (Agaricales) from New Zealand, Papua New Guinea and Argentina. – Sydowia 40: 168–187.

— & W. Steglich (1987). 4-Aminophyscion, an anthraquinone derivative from *Dermocybe* (Agaricales). – Phytochemistry 26: 2119–2121.

Kidd, C. B. M., B. Caddy, J. Robertson, I. R. Tebbett & R. Watling (1985). Thin-layer chromatography as an aid for identification of *Dermocybe* species of *Cortinarius*. – Trans. Br. mycol. Soc. 85: 213–221.

Moser, M. (1972). Die Gattung *Dermocybe* (Fr.) Wünsche. – Schweiz. Z. Pilzkunde 50: 153–167.

— (1985). The relevance of chemical characters for the taxonomy of Agaricales. – Proc. Indian Acad. Sci. (Plant Sci.) 94: 381–386.

— in Singer, R. (1986). The Agaricales in modern taxonomy. – 981 pp. (Koeltz, Scientific Books), p. 653–656.

— & E. Horak (1975). *Cortinarius* Fr. und nahe verwandte Gattungen in Südamerika. – Nova Hedwigia Beih. 52: 1–628.

— & H. Keller-Dilitz (1983). *Cortinarius raphanoides* Pers.: Fr. and related species. – Cryptogamie, Mycologie 4: 41–50.

Steglich, W. & B. Oertel (1984). Untersuchungen zur Konstitution und Verbreitung der Farbstoffe von *Cortinarius*, Untergattung *Phlegmacium* (Agaricales). Sydowia 37: 284–295.

Thomson, R. H. (1987). Naturally occurring quinones III recent advances. Chapman & Hall, London, New York, 372 pp.

(Manuscript accepted 20th June 1994)

Zeitschrift/Journal: Sydowia Beihefte

Jahr/Year: 1995

Band/Volume: 10

Autor(en)/Author(s): Gill M.

Artikel/Article: New pigments of Cortinarius Fr. and Dermocybe (Fr.) Wünsche (Agaricales) from Australia and New Zealand 73-87