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DITERPENES AND 5-METHYL COUMARIN DERIVATIVES FROM *GYPOTHAMNIUM PINIFOLIUM* AND *PLAZIA DAPHNOIDES*

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Key Word Index—*Gypothamnium pinifolium*, *Plazia daphnoides*; Compositae; 5-methyl coumarins and coumaranones; sesquiterpene derivatives; diterpenes; *ent*-labdanes; syringenin derivative.

Abstract—The aerial parts of *Gypothamnium pinifolium* afforded, in addition to three known 5-methyl coumarins, four new 5-methyl coumarins and two closely related coumaranones. Furthermore, seven diterpenes, all derived from ent-labda-8,13-diene-15-ol, were isolated. The aerial parts of *Plazia daphnoides* gave large amounts of 5-methyl coumarins, kolavenol, flavanoids and 9-acetoxycapric acid. The structures were elucidated by high field NMR techniques. The chemotaxonomic relevance of the 5-methyl coumarins is discussed.

INTRODUCTION

From the tribe Mutisieae several characteristic groups of natural products have been isolated which in part are typical for the subtribe where the corresponding genera have been placed [1]. However, there are several exceptions where systematic proposals do not agree with the chemistry. We are, therefore, studying representatives of further genera which so far have not been investigated chemically. In this paper we report the results on *Gypothamnium pinifolium* Phil. and *Plazia daphnoides* Wedd., both placed in the subtribe Gochnatiinae [1].

RESULTS AND DISCUSSION

The aerial parts of *G. pinifolium* afforded, in addition to lupeyl acetate and umbelliferone, the 5-methyl coumarins **1**, **2**, **5** [2], **6**, **7** [3], **8** and **9** [3], the closely related coumaranones **3** and **4**, the syringenin derivative **10** and the *ent*-labdanes **11** [4], **12**–**16** as well as the seco derivative **17** and the closely related methyl ketone **18**.

The ^{1}H NMR spectrum (Table 1) of the coumarin **1** showed that a 5-methyl-4-hydroxy coumarin was present. As the molecular formula was $C_{25}H_{30}O_5$ a sesquiterpene side chain was very likely. This was established by spin decoupling of the corresponding ^{1}H NMR signals and by the observed chemical shifts and couplings of the remaining signals. In the spectrum of **1**, assignment of H-2′ followed from the coupling with a two proton doublet at δ 3.44 attributable to H-1′. As an allylic coupling between H-2′ and H-4′ was observed further decoupling allowed the assignment of H-5′ and H-6′. The chemical shift of H-6′ (δ6.54) required a keto group at C-8′. Thus the signals at δ 5.28 and 4.97 were due to H-9′ and H-10′. This was established by the presence of allylic couplings of H-10′ with H-12′ and H-13′. The spectrum of the diacetate **1a** also led to the same conclusions.

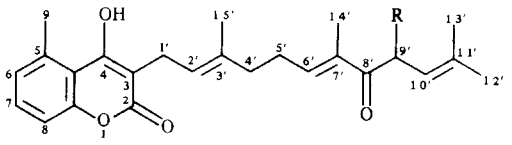
The ^{1}H NMR spectrum of **2** (Table 1) together with its molecular formula ($C_{25}H_{30}O_4$) indicated that this coumarin was the 9′-desoxy derivative of **1**. Spin decoupling established this assumption.

The ^{1}H NMR spectrum of **6** (Table 1) was close to that of **5**. However, due to an additional double bond the signals of an isovaleryl side chain were replaced by those of a senecioyl group.

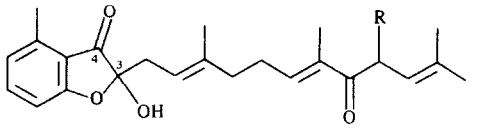
Compound **7** had only been isolated as its acetate **7a**. We therefore have included its ^{1}H NMR data in Table 1. The corresponding data of **8** (Table 1) were in part close to those of cyclolycoserone [2]. However, the changed side chain was indicated by a pair of doublets for *trans*-orientated olefinic protons and the chemical shift of H-12′, H-13′ required a hydroxy group at C-11′.

The spectral data of **3** and **4** indicated the presence of coumaranone derivatives. Accordingly, the ^{1}H NMR spectra (Table 1) were similar to that of the corresponding desoxo compound of **3** [5]. The position of the oxygen functions was determined by spin decoupling in deuteriobenzene where all signals could be assigned. In the case of the ketone **4**, irradiation of the broadened triplet at δ 5.61 collapsed the broadened doublet at δ 3.34 to a singlet and simultaneously sharpened two methyl singlets (H-12′ and H-13′). Similarly the whole sequence of the 8′-oxofarnesyl residue could be determined. In the spectrum of **4** the signal at δ 3.34 was replaced by a broadened double doublet at δ 5.43 which was coupled with an olefinic proton (δ 5.12) and a hydroxyl proton (δ 3.29). Thus ketone **4** was the 9′-hydroxy derivative of **3**. As following from the fact that some methyl signals were doubled, compound **4** was a mixture of 3- or 9′-epimers respectively.

The ^{1}H NMR spectrum of compound **10** (see Experimental) showed that a farnesyl derivative was present. The nature of the remaining part of the molecule followed from the base peak (*m/z* 210 [$M-C_{15}H_{24}$]) and from comparison of the ^{1}H NMR signals with those of similar syringenin derivatives [6]. Furthermore, the ^{13}C NMR spectrum supported the proposed structure which also indicated the configurations of the farnesyl double bonds (see Experimental).



1 R = OH
2 R = H



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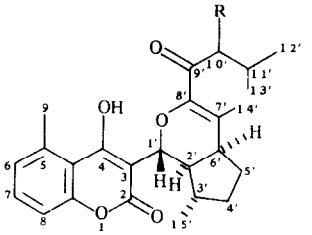
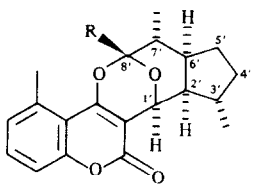
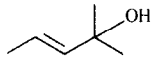
4 R = OH



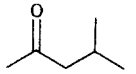
5 R = H
5a R = H, 1′*epi*
6 R = H, $\Delta^{10'}$
7 R = OH



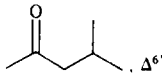
8 R =



8a R =



8b R =



The spectral data and the optical rotation of **11**, which has been isolated from an *Araucaria species*, showed that the main compound was identical with the known *ent*-labdane derivative [4]. Accordingly, it was very likely that all the other minor diterpenes were *ent*-labdanes.

The ^{1}H NMR spectrum of **12** (Table 2) showed that a 7-keto derivative of **11** was present as followed from the results of spin decoupling. A double doublet at δ 1.70 was coupled with a pair of double doublets at δ 2.35 and 2.49. The chemical shift of the latter signals required a neighbouring keto group and the coupling of the signal at δ 1.70 only agreed with those expected for H-5 as there is no other possibility in the molecule for the observed sequence.

The compounds **13** and **14** were isolated as their diacetates **13a** and **14a**. The ^{1}H NMR spectra (Table 2) did not allow direct assignment of the relative positions of the secondary oxygen functions, especially as several signals were overlapped multiplets. However, spin decoupling and NOE difference spectroscopy allowed the assignment of the relative positions. Thus in the case of **13a** saturation of the signal of the proton under the secondary acetoxy group (δ 5.62 *br dd*) gave effects with H-5 and H-6β. As irradiation of H-17 gave NOE's with H-6β and H-7 the position of the acetoxy group was settled. Further NOE's allowed the assignment of the methyl singlets and established the *E*-configuration of the Δ^{13} bond. The observed couplings of H-7 required an equatorial oxygen function. Similarly in the case of the epimer **14a**, H-7 showed NOE's with H-6β and H-17, and H-6β with H-5, H-7 and H-18. The small coupling of H-7 indicated an axial orientation of the acetoxy group.

The ^{1}H NMR spectrum of **15** and of its diacetate **15a** (Table 2) differed markedly from those of **13** and **14**. In particular the signals of the side chain showed a very different picture while those the ring protons were similar to those of **11** indicating that no functions were at C-1–C-9. Spin decoupling showed that a pair of double doublets at δ 3.71 and 3.54 in the case of **15** were due to H-15 as the vicinal proton was a broadened double doublet at δ 4.22 which on irradiation sharpened a pair of broadened singlets at δ 5.13 and 5.01, obviously the signals of H-16. Some line broadenings and double signals for H-17 and H-20 in the spectra of **15** and **15a** indicated that epimers at C-14 were present. The ^{1}H NMR spectrum of **16** and of its acetate **16a** (Table 2) showed that an *ent*-labdane with a 8(17)-exomethylene bond was present. The 9-hydoxy group led to a favoured formation of *m/z* 220 ($C_{15}H_{24}O$). The β-configuration of the hydroxy group was deduced from the chemical shift of H-20 which would be deshielded by a 9α-hydroxy group. Also biogenetic considerations favour this stereochemistry as most likely carbinol **16** was formed by attack of oxygen from the less hindered side of **11**.

The ^{1}H NMR spectrum of **17** and of the corresponding acetate **17a** (Table 2) differed in a characteristic manner from those of **11** and **11a**. The presence of a similar side chain followed from the nearly identical signals for H-14, H-15 and H-16 in both compounds. However, the olefinic methyl signal (H-17) was replaced by a sharp methyl singlet at δ 2.08 in the spectrum of **17a**. The ^{13}C NMR spectrum indicated the presence of two keto groups with two methylene, one methyl and one quarternary neighbouring carbon. Furtheremore, in the ^{1}H NMR spectrum A_2B_2 systems for H-7, H-11 and H-12 were observed. The proposed structure was strongly supported by the fragmentation pattern in the mass spectrum of **17a**. Thus elimination of $CH_2CH_2C(Me)=CHCH_2OAc$ followed by loss of CO and then of acetone was observed.

The last diterpene **18** also was transformed to an acetate (**18a**). The ^{1}H NMR spectra (Table 2) again indicated that a methylketone was present, however, a neighbouring proton was present (δ 2.87 *dd*). These couplings and those of the vicinal protons indicated the presence of a five-membered ring. In agreement with the molecular formula, a 9β-hydroxy group was proposed which was indicated by the downfield shift of the H-5 signal. The stereochemistry was determined by the observed NOE's between H-20, H-6α and H-7α, between H-19 and H-6α, between H-7α, H-17 and H-20, between H-5, H-18 and OH as well as between H-16 and H-15. Again the fragmentation pattern supported the proposed structure by favoured loss of $CH_2CH_2C(Me)=CHCH_2OAc$. Obviously the ketone **18** was formed by aldol condensation of **17**. We have proposed for the ketone **18** the name gypopinifolone.

The aerial parts of *Plazia daphnoides* afforded large amounts of kolavenol, the flavanoids naringenin, sakur-

Table 1. ^{1}H NMR spectral data of the 5-methyl coumarins (400 MHz, $CDCl_3$, δ-values)

H	1	1a	2	3 (C_6D_6)	4 (C_6D_6)	6	7*	8
6	7.03 *br d*	7.03 *br d*	7.03 *br d*	6.42 *br d*	6.33 *br d*	7.07 *br d*	7.09 *br d*	7.05 *br d*
7	7.35 *t*	7.35 *t*	7.35 *t*	6.89 *t*	6.91 *t*	7.41 *t*	7.43 *t*	7.37 *t*
8	7.16 *br d*	7.21 *br d*	7.16 *br d*	6.67 *br d*	6.61 *br d*	7.19 *br d*	7.21 *br d*	7.19 *br d*
9	2.69 *s*	2.58 *s*	2.67 *s*	2.52 *s*	2.52 *s*	2.75 *s*	2.74 *s*	2.74 *s*
1′	3.44 *br d*	3.17 *br d*	3.45 *br d*	2.75 *dd* 2.63 *dd*	2.74 *dd* 2.60 *dd*	4.84 *dd*	4.83 *d*	5.05 *br s*
2′	5.35 *br t*	5.18 *br t*	5.40 *br t*	5.32 *br t*	5.32 *br t*	2.14 *m*	2.15 *m*	1.71 *m*
3′	—	—	—	—	—			2.06 *m*
4′	2.24 *br t*	2.11 *br t*	2.29 *br t*	1.79 *br t*	1.78 *br t*	2.00 *dddd* 1.16 *dddd*	2.00 *m* 1.15 *m*	‡
5′	2.41 *br q*	2.33 *br q*	2.41 *br q*	1.92 *br q*	1.87 *br q*	2.21 *dddd* 1.49 *dddd*	2.02 *m* 1.50 *m*	‡
6′	6.54 *br t*	6.56 *br t*	6.57 *br t*	6.31 *br t*	6.28 *br t*	2.58 *ddd*	2.28 *ddd*	‡
9′	5.28 *dd*	6.20 *d*	3.33 *br d*	3.34 *br d*	5.43 *br dd*	—	—	5.96 *d*
10′	4.97 *dqq*	5.14 *dqq*	5.25 *tqq*	5.61 *br t*	5.12 *br d*	6.40 *qq*	4.53 *dd*	6.23 *d*
12′	1.84 *d*	1.78 *d*	1.70 *br s*	1.69 *br s*	1.70, 1.68 *br s*	2.17 *d*	1.00 *d*	1.37 *s*
13′	1.72 *d*	1.75 *d*	1.60 *br s*	1.59 *br s*	1.53 *br s*	1.90 *d*	0.67 *d*	
14′	1.83 *br s*	1.77 *s*	1.79 *br s*	1.77 *br s*	1.73, 1.72 *br s*	2.08 *s*	2.14 *d*	1.17 *d*
15′	1.87 *br s*	1.77 *s*	1.90 *br s*	1.47 *br s*	1.41, 1.40 *br s*	0.88 *d*	0.90 *d*	1.03 *d*
OAc	—	2.40 *s* 2. 08 *s*	—	—	—	—	—	—
OH	3.94 *d*	—	—	—	3.29 *br d*	9.12 *s*	3.32 *d*	

*H-11 1.98 *m*; in C_6D_6 2.15 *dqq*; ‡obscured signals.

J [Hz]: 6,7 = 7,8 = 8; compounds **1**, **1a** and **2**: 1′,2 = 4′,5′ = 5′,6′ = 7; 10′,12′ = 10′,13′ = 1; compounds **1** and **1a**: 9′,10′ = 10; (compound **1**: 9′, OH = 6); compound **2**: 9′,10′ = 7; compounds **3** and **4**: 1′,2′ = 4′,5′ = 5′,6′ = 9′,10′ = 7; (compound **4**: 9′,10′ = 10; 9, OH = 6); compounds **6** and **7**: 1′,2′ = 11; 3′,4′$_1$ = 7; 3′,4′$_2$ = 11; 3′,15′ = 7; 4′$_1$,4′$_2$ = 13; 4′$_1$,5 = 7; 4′$_1$,5′$_2$ = 11; 4′$_2$,5′$_1$ = 2; 4′$_2$,5′$_2$ = 7; 5′$_1$,5′$_2$ = 13; 5′$_1$,6′ = 7; 5′$_2$,6′ = 11; 10′,12′ = 10′,13 = 1; (compound **7**: 10′,11′ = 2.5; 10′, OH = 11′,12′ = 11′,13′ = 7); compound **8**: 9,10′ = 15.5.

anetin, isosakuranetin, acacetin and genkwanin, lupeyl acetate, α- and γ-curcumene, (−)-9-acetoxycapric acid, the 5-methyl coumarins lycoserone (**5**) [2] and its 1′-epimer **5a** [2], cyclolycoserone (**8a**) [2] and its dehydro derivative **8b** [2].

The isolation of 5-methyl-4-hydroxycoumarin derivatives from *Gypothamnium* and *Plazia* species indicates again that this type of rare coumarin is characteristic for several groups of genera in the tribe Mutisieae though such compounds have been reported from a few genera of the tribe Vernonieae. However, 5-methyl coumarins linked with a sesquiterpene moiety are restricted to the tribe Mutisieae, mainly from the subtribe Gochnatiinae [2, 3].

The distribution of all 5-methyl coumarins in the tribe Mutisieae are listed in Table 3. Probably the ability to produce this type of coumarin is a very ancient one and may indicate a relationship between the tribe Vernonieae and Mutisieae, both placed in the subfamily Cichorioideae.

In the subtribe Barnadesiinae, which has recently been separated from the tribe and even from the subfamily [20–22], these compounds have not been isolated. All characteristic compounds are missing in this group [23] which is said to be the most primitive one in the Compositae [20–22]. This was shown again by the investigation of *Doniophyton anomalum* (D. Don) Kurtz which only afforded lupeol and its fatty acid esters.

The accumulation of *ent*-labdanes in the *Gypothamnium* and the large amounts of a clerodane derivatives present in *Plazia* species is exceptional, as in general diterpenes seems to be more or less absent in the subfamily Cichorioideae while they are very common in the Asteroideae. As shown previously, there are several other types of natural products which are characteristic for the tribe Mutisieae [24] which taken together are useful for delimitation of the subtribes in this taxonomically difficult tribe.

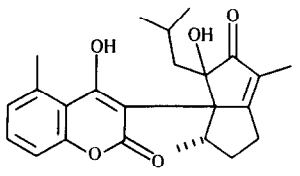
EXPERIMENTAL

The extract of the aerial parts of *Gypothamnium pinifolium* (670 g, collected 7 km E of Tal Tal in February 1987, voucher Conc. 72993) was defatted by treatment with MeOH and separated first by CC (silica gel) into six fractions [1: Et_2O–petrol (1:3); 2: Et_2O–petrol (3:1); 3: Et_2O; 4: Et_2O; 5: Et_2O–MeOH (9:1) and 6: Et_2O–MeOH (9:1)]. Fraction 1 contained *ca* 1.5 g lupeyl acetate; fraction 2 9 g **6** and fraction 3 7.5 g **11**. Fractions 4 and 5 were mixtures and fraction 6 gave 1.2 g **1**. Medium pressure CC (silica gel, ϕ 30–60μ) of fraction 4 [Et_2O–petrol mixtures, finally Et_2O–MeOH (9:1)] gave seven fractions (4/1–4/7). Fraction 4/1 gave 200 mg **6** and fraction 4/2 by TLC [Et_2O–petrol (1:1)] 0.5 g **11** and 150 mg **7**. TLC of fraction 4/3 (same solvent) gave 50 mg **7** and HPLC of fraction 4/4 [MeOH–H_2O (4:1), always RP 8, *ca* 100 bar, flow rate 3 ml/min] four fractions (4/4/1–4/4/4). TLC of 4/4/1 [Et_2O–petrol (1:1), two developments] gave 5 mg **9** and 3 mg **3** (R_f 0.50) while TLC of 4/4/2 [Et_2O–petrol (1:1)] yielded 6 mg **2** (R_f 0.60). Fraction 4/4/3 was acetylated (Ac_2O, 1 hr, 70°) and

Table 2. ^{1}H NMR spectral data of compounds **12**–**18** and the corresponding acetates (400 MHz, $CDCl_3$, δ-values)

H	**12**	**12a**	**13a** (C_6D_6)	**14a** (C_6D_6)	**15**	**15a**	**16**	**16a**	**17a**	**18a**‡
5	1.70 *m*	1.70 *dd*	1.17 *dd*	1.60 *m*	*	*	*	*	*	2.11 *dd*
6α	2.35 *dd*	2.35 *dd*	1.59 *m*		*	*	*	*	1.63 *m*	1.90 *ddd*
6β	2.49 *dd*	2.50 *dd*	2.31 *ddd*	1.92 *br d*	1.96 *dd*	1.94 *dd*			*	1.65 *m*
7	—	—	5.62 *br dd*	5.40 *br d*	2.05 *m*	2.05 *m*	2.15 *m*	2.15 *m*	2.44†	2.87 *dd*
11							*	*		
11′		2.32 *m*	2.2–2.0 *m*	2.15–1.95 *m*	2.2–2.0 *m*	2.1–1.9 *m*	*	*	2.59†	1.65 *m*
12		2.15 *m*					2.45 *ddd*	2.45 *ddd*	2.25†	2.19 *ddd*
12′							2.15 *m*	2.15 *m*		1.94 *ddd*
14	5.46 *br t*	5.46 *br t*	5.53 *br t*	5.50 *br t*	4.22 *br dd*	5.41 *dd*	5.44 *br t*	5.37 *br t*	5.33 *br t*	5.32 *br t*
15	4.18 *br d*	4.60 *br d*	4.69 *br d*	4.68 *br d*	3.71 *dd*	4.25 *dd*	4.16 *br d*	4.59 *br d*	4.57 *br d*	4.57 *br d*
					3.54 *dd*	4.12 *dd*				
16	1.73 *br s*		1.60 *br s*	1.57 *br s*	5.13 *br s*	5.10 *br s*	1.71 *br s*	1.73 *br s*	1.70 *br s*	1.69 *br s*
					5.01 *br s*	5.03 *br s*				
17	1.76 *br s*	1.76 *br s*	1.65 *br s*	1.65 *br s*	1.55 *br s*	1.56 *br s*	4.95 *br s*	4.95 *br s*	2.08 *s*	2.23 *s*
					1.56 *br s*	1.55 *br s*	4.64 *br s*	4.64 *br s*		
18	0.92 *s*	0.92 *s*	0.85 *s*	0.83 *s*	0.87 *s*	0.87 *s*	0.83 *s*	0.83 *s*	0.91 *s*	0.89 *s*
19	0.88 *s*	0.89 *s*	0.80 *s*	0.79 *s*	0.83 *s*	0.83 *s*	0.82 *s*		0.89 *s*	0.87 *s*
20	1.08 *s*	1.09 *s*	1.00 *s*	0.92 *s*	0.93 *s*	0.93 *s*	0.90 *s*	0.90 *s*	1.22 *s*	0.85 *s*
					0.94 *s*	0.94 *s*				
OAc	—	2.06 *s*	1.83 *s*	1.81 *s*		2.10 *s*	—	2.06 *s*	2.05 *s*	2.05 *s*
			1.75 *s*	1.75 *s*		2.05 *s*				

*Obscured multiplets; †A_2B_2 system; ‡OH 4.90 *s*, H-1α 1.30 *br d*, H-1β 1.65 m, H-2 1.55 *m*, H-2 1.55 *m*, H-3α 1.41 *br d*, H-3β 1.12 *dt*; *J* [Hz]: 14,15 = 7; compounds **12** and **12a**: 5,6α = 14; 5,6β = 3.5; 6α,6β = 17; compound **13a**: 5,6α = 13; 5,6β = 1.5; 6α,6β = 13; 6α,7 = 6β,7 = 7; compound **14a**: 6α,6β = 13; 6α,7 = 4; compounds **15**/**15a**: 6,7′ = 7; 7,7′ = 17; 14,15 = 3; 14,15′ = 7; 15,15′ = 11; compounds **16**/**16a**: 11,12 = 12,12′ = 13; 11′,12 = 6; compound **18a**: 5,6α = 12; 5,6β = 8; 6α,6β = 6α,7 = 12; 6β,7 = 5; 11,12 = 12,12′ = 13; 11′,12 = 11,12′ = 6.



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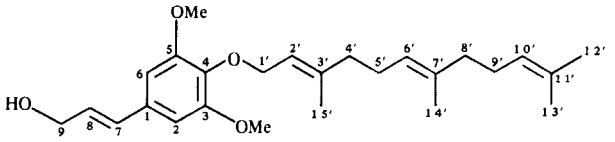

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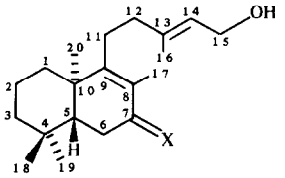
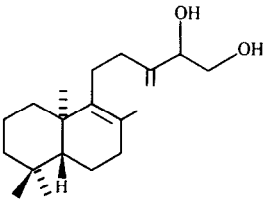
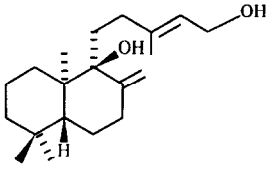


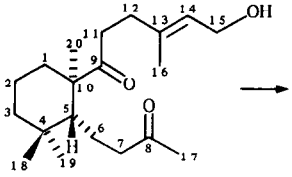
11 X = H_2
12 X = O
13 X = αOH, H
14 βOH, H



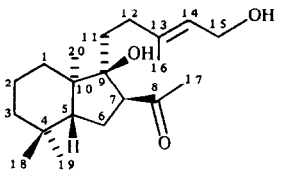
15



16



17



18

1a and **11a–18a** are the corresponding acetates

TLC (Et_2O–petrol (1:3)] then gave 8 mg **16a**. Fraction 4/4/4 after acetylation (Ac_2O, 1 hr, 70°) gave by TLC [Et_2O–petrol (1:3)] 12 mg **15a** (R_f 0.70). HPLC of fraction 4/5 [MeOH–H_2O (4:1)] gave five crude fractions (4/5/1–4/5/5). Fraction 4/5/1 was acetylated (Ac_2O, 1 hr, 70°), after which TLC [Et_2O–petrol (1:1)] gave 12 mg **17a** (R_f 0.75). Fraction 4/5/2 gave by TLC [Et_2O–petrol (3:1)] a mixture which gave by repeated TLC [$CHCl_3$–C_6H_6–Et_2O (2:2:1) 2 mg **12**, which gave by acetylation (Ac_2O, 1 hr, 70°) **12a**. TLC of fraction 4/5/3 [Et_2O–petrol (3:1)] afforded 2 mg **3** (R_f 0.75), 6 mg **2** (R_f 0.60) and 2 mg **13** (R_f 0.45). TLC of fraction 4/5/4 (Et_2O–petrol (3:1)] gave 3 mg **8** (R_f 0.62) and 2 mg **16** (R_f 0.45). HPLC of fraction 4/5/5 [MeOH–H_2O (4:1)] yielded 12 mg **15** (R_t 12.7 min) and 6 mg **10** (R_t 14.7 min). Fraction 4/6 gave 70 mg umbelliferone and fraction 4/7 100 mg **1**. Medium pressure CC of fraction 5 gave 300 mg **6**, 100 mg **7**, 300 mg **1** and a mixture which was acetylated (Ac_2O, DMAP, $CHCl_3$, 1 hr, 65°) to give by TLC [Et_2O–petrol (1:1)] 2 mg **16a** purified by HPLC [MeOH–H_2O (17:3), R_t 2.1 min], 8 mg **17a** [HPLC MeOH–H_2O (17:3), R_t 1.7 min], 50 mg **1a**, 30 mg umbelliferone acetate and a mixture which gave by HPLC [MeOH–H_2O (17:3)] 6 mg **13a** (R_t 4.6 min) and 5 mg **14a** (R_t 4.1 min).

The extract of the aerial parts of *Plazia daphnoides* (voúcher 2551, collected in January 1986 near Putre, Chile) gave by CC and TLC (as above) 500 mg α- and 500 mg γ-curcumene, 500 mg lupeyl acetae, 5 g kolavenol, 6 g sakuranetin, 4 g naringenin, 1 g isosakuranetin, 500 mg acacetin, 200 mg genkwanin, 2 g **8b**, 300 mg **8a**, 2.7 g **5** and 500 mg **5a** as well as 1.1 g 9-acetoxycapric acid; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3500–2600, 1712 (CO_2H), 1735, 1250 (OAc); CIMS *m/z* (rel. int.): 231 $[M+1]^+$ (100), 171 $[231-HOAc]^+$ (28), 153 $[171-H_2O]^+$ (18), 135 $[153-CO]^+$ (4); ^{13}C NMR ($CDCl_3$, C-1–C-10, assignment by 2D): δ 179.8, 34.0, 24.6, 29.2, 29.1, 28.9, 25.3, 35.8, 71.1, 19.9; OAc: 171.1, 21.4; ^1H NMR ($CDCl_3$): δ 2.34 (*t*, H-2), 1.62 (*tt*, H-3), 1.30 (*m*, H-4–H-7), 1.57 and 1.47 (*m*, H-8), 4.88 (*tq*, H-9), 1.20 (*d*, H-10), 2.03 (*s*, OAc); (*J* [Hz]: 2,3 = 3,4 = 8,9 = 9,10 ~ 7); $[\alpha]_D^{24°}$ −1.3 ($CHCl_3$; *c* 2.2).

The extract from 400 g of the aerial parts of *Doniophyton anomalum* (voucher Conc. 72986, collected in February 1987 near Embalse La Laguna, Chile) afforded by CC 80 mg lupeol and 100 mg lupeyl fatty acid esters. Known compounds were identified by comparing the 400 MHz H NMR spectra with those of authentic material.

4-Hydroxy-5-methyl-3-[8'-oxo-9'-hydroxyfarnesyl]-coumarin (**1**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3500–2800, 1710, 1620, 1600

Table 3. Distribution of 5-methyl-4-hydroxycoumarin and chromone derivatives in the Mutisieae

Genus	Simple	Substituted with C_5	C_{10}	C_{15}	Ref.
Gochnatiinae					
Aphylloclados				++	[3]
Gypothamnium				++	
Lycoseris				++	[2]
Onoseris	+		+		[7]
Plazia				++	
Mutisiinae					
Brachyclados			++		[5]
Gerbera	+	+	+		[8–10]
Mutisia			+	+	[5, 11]
Trichocline		+			
Nassauviinae					
Dolichlasium	+		+		[12]
Jungia	+		+		[13]
Nassauvia				+	[12]
Perezia	++		+		[14–18]
Trixis			+		[19]
Triptilion				++	

(hydroxycoumarin), 3440 (OH), 1670 (C=C–C=O); MS *m/z* (rel. int.): 410.209 $[M]^+$ (2.5) (calc. for $C_{25}H_{30}O_5$: 410.209), 392 $[M-H_2O]^+$ (3.5), 269 (37), 189 (63), 177 (75), 135 (54), 83 (100); acetylation (Ac_2O, DMAP, $CHCl_3$, 1 hr, 70°) afforded the diacetate **1a**; colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1780, 1740 (OAc), 1685 (C=C–C=O); MS *m/z* (rel. int.): 494.230 $[M]^+$ (3.5) (calc. for $C_{29}H_{34}O_7$: 494.230), 452 $[M-ketene]^+$ (2), 434 $[M-HOAc]^+$ (4) 392 $[434-ketene]^+$ (6), 367 (36), 325 $[M-CH(OAc)\ CH{=}CMe_2$ (64), 297 $[325-CO]^+$ (32), 269 $[297-CO]^+$ (92), 243 (52), 189 $[C_{11}H_9O_3]^+$ (100), 177 $[C_{10}H_9O_3]^+$ (34), 135 $[C_8H_7O_2]^+$ (94), 109 (81); $[\alpha]_D^{24}$ −19 ($CHCl_3$; *c* 2.19).

4-*Hydroxy*-5-*methyl*-3-[8′-*oxo*-*farnesyl*]-*coumarin* (**2**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3500–2800, 1710, 1620, 1600 (hydroxycoumarin), 1670 (C=C–C=O); MS *m/z* (rel. int.): 394.214 $[M]^+$ (3.5) (calc. for $C_{25}H_{30}O_4$: 394.214), 325 (22), 269 (40), 189 (57), 177 (70), 135 (100), 109 (84), 81 (90), 69 (95).

3-*Hydroxy*-5-*methyl*-2-[8′-*oxo*-*farnesyl*]-*coumaran*-3-*one* (**3**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3560 (OH), 1730, 1660 (C=O); MS *m/z* (rel. int.): 382.214 $[M]^+$ (4) (calc. for $C_{24}H_{30}O_4$: 382.214), 313 (34), 295 (24), 267 (28), 239 (45), 163 (84), 135 (100), 95 (83), 69 (98).

3-*Hydroxy*-5-*methyl*-2-[8′-*oxo*-9-*hydroxyfarnesyl*]-*coumaran*-3-*one* (**4**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3400 (OH), 1720, 1660 (C=O); MS *m/z* (rel. int.): 398.209 $[M]^+$ (1.3) (calc. for $C_{24}H_{30}O_5$: 398.209), 380 (1.8), 313 (16), 267 (14), 239 (31), 163 (50), 135 (100), 83, (94).

10′,11′-*Dehydro*-1′β*H*-*lycoserone* (**6**). Colourless crystals, mp 164°; IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3500 (OH), 3500–2800, 1690, 1610 (hydroxycoumarin), 1690 (C=C–C=O); MS *m/z* (rel. int.): 408.194 $[M]^+$ (calc. for $C_{25}H_{28}O_5$: 408.194), 390 (3), 325 (34), 297 (12), 229 (18), 189 (37), 135 (31), 83 (100); $[\alpha]_D^{24}$ +385 ($CHCl_3$; *c* 0.97).

10′-*Hydroxy*-1′β*H*-*lycoserone* (**7**). Colourless crystals, mp 182°; IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3460 (OH), 3500–2800, 1690, 1620, 1605 (hydroxycoumarin), 1690 (C=CC=O); MS *m/z* (rel. int.): 426.204 $[M]^+$ (8) (calc. for $C_{25}H_{30}O_6$: 426.204), 408 (5), 325 (41), 246 (28), 229 (37), 189 (83), 177 (54) 135 (100); $[\alpha]_D^{24}$ +274 ($CHCl_3$; *c* 0.54). Acetylation (see above) afforded the acetate **7a**, identical with a product reported previously [3].

Gypothamniol (**8**). Colourless oil: IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3580 (OH), 1717, 1625, 1600 (coumarin); MS *m/z* (rel. int.): 410.209 $[M]^+$ (48) (calc. for $C_{25}H_{30}O_5$: 410.209), 392 (80), 377 (51), 336 (46), 297 (40), 296 (38), 268 (56), 267 (100), 189 (64), 135 (15); $[\alpha]_D^{24}$ +58 ($CHCl_3$; *c* 0.44).

Syringenin-4-*O*-*farnesylether* (**10**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3600 (OH), 1590 (aromate), 970 (trans CH=CH); MS *m/z* (rel. int.): 414.277 $[M]^+$ 0.1) (calc. for $C_{26}H_{38}O_4$: 414.277), 210. 090 $[M-C_{15}H_{24}]^+$ (100) (calc. for $C_{11}H_{14}O_4$: 210.090), 81 (81), 69 (56); ^1H NMR ($CDCl_3$): δ 6.60 (*s*, H-2, H-6), 6.53 (*dt*, H-7), 6.28 (*dt*, H-8), 4.32 (*br d*, H-9), 4.53 (*d*, H-1′), 5.57 (*br t*, H-2′), 5.10 (*br t*, H-6′), 5.08 (*br t*, H-10′), 1.65 (*br s*, H-12′), 1.59 (*br s*, H-13′), 1.60 (*br s*, H-14′), 1.68 (*br s*, H-15′), 3.85 (s, OMe); (*J* [Hz]: 7,8 = 16; 7,9 = 1; 8,9 = 5.5; 1′, 2′ = 5′,6′ = 9′,10′ = 7); ^{13}C MMR ($CDCl_3$, C-1–C-9): δ 131.3, 103.5, 153.7, 136.8, 153.7, 103.5, 141.4, 131.3, 69.5; (C-1′–C-15′): δ 63.7, 120.2, 135.2, 39.7, 26.4, 124.0, 132.3, 39.6, 26.7, 124.4, 131.3, 25.8, 17.7, 16.4, 16.0; OMe: 56.0.

7-*oxo*-*ent*-*labda*-8,13E-*diene*-15-*ol* (**12**). Colourless oil which was purified as its acetate **12a** (Ac_2O, 1 hr, 70°); colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1735, 1230 (OAc), 1665 (C=C–C=O); MS *m/z* (rel. int.): 346.251 $[M]^+$ (11) (calc. for $C_{22}H_{34}O_3$: 346.251), 331 (10), 286 (41), 271 (26), 220 (61), 205 (78), 135 (100), 123 (74); $[\alpha]_D^{24}$ −36 ($CHCl_3$, *c* 0.59).

7α,15-*Dihydroxy*-*ent*-*labda*-8,13E-*diena* (**13**). Purified as its diacetate **13a** (see above); colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1740, 1240 (OAc); MS *m/z* (rel. int.): 330.256 $[M-HOAc]^+$ (1) (calc. for $C_{22}H_{34}O_2$: 330.256), 262 (36), 221 (45), 220 (100), 203 (12); $[\alpha]_D^{24}$ −26 ($CHCl_3$; *c* 0.56).

7β,15-*Dihydroxy*-*ent*-*labda*-8,13E-*diene* (**14**). Purified as its diacetate **14a** (see above); colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1740, 1240 (OAc); MS *m/z* (rel. int.): 330.256 $[M-HOAc]^+$ (0.7) (calc. for $C_{22}H_{34}O_2$: 330.256), 262 (52), 221 (78), 220 (100), 203 (17), 119 (64); $[\alpha]_D^{24}$ −59 ($CHCl_3$; *c* 0.42).

14,15-*Dihydroxy*-*ent*-*labda*-8,13 (16)-*diene* (**15**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3600 (OH), 1645 (C=C); MS *m/z* (rel. int.): 306.256 $[M]^+$ (19) (calc. for $C_{20}H_{34}O_2$: 306.256), 291 (12), 205 (58), 191 (64), 109 (98), 95 (92), 69 (100); $[\alpha]_D^{24}$ −61 ($CHCl_3$; *c* 0.82). Acetylation (see above) afforded the diacetate **15a**; colourless oil; MS *m/z* (rel. int.): 390.277 $[M]^+$ (12) (calc. for $C_{24}H_{38}O_4$: 390.277), 375 (10), 330 (8), 288 (14), 270 (12), 255 (28), 205 (42), 191 (40), 149 (74), 135 (100), 109 (71), 95 (70), 69 (96).

9β,15-*Dihydroxy*-*ent*-*labda*-8 (17),13E-*diene* (**16**). Purified as its acetate **16a** (see above); colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3600 (OH), 1740, 1235 (OAc); MS *m/z* (rel. int.): 288.245 $[M-HOAc]^+$ (92) (calc. for $C_{20}H_{32}O$: 288.245), 220 (22), 205 (18), 164 (44), 151 (92), 109 (100), 95 (70), 81 (70), 69 (79).

15-*Hydroxy*-8,9-*dioxo*-*seco*-*ent*-*labd*-13E-*ene* (**17**). Purified as its acetate **17a** (see above); colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1740, 1240 (OAc), 1720 (C=O); MS *m/z* (rel. int.): 364 $[M]^+$ (0.6), 304.240 $[M-HOAc]^+$ (8) (calc. for $C_{20}H_{32}O_5$: 304.240), 289 (5), 223 $[M-CH_2CH_2C\ (Me){=}CHCH_2OAc]^+$ (12), 195 $[223-CO]^+$ (44), 177.164 $[C_{13}H_{21}]^+$ (100), 137 $[195-Me_2CO]^+$ (38), 109 (64), 69 (76); $[\alpha]_D^{24}$ −4 ($CHCl_3$; *c* 2.86); ^{13}C NMR ($CDCl_3$, C-1–C-20): 33.4, 22.3, 35.8, 34.4, 47.6, 18.2, 45.6, 209.0, 216.0, 53.1, 41.1, 37.0, 141.2, 118.7, 61.2, 17.2, 33.4, 30.0, 22.5, 16.7; OAc: 21.0, 171.1.

Gypopinifolone (**18**). Colourless oil which was transformed to the acetate **18a** (see above); colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3440 (OH), 1740, 1240 (OAc), 1695 (hydrogen bonded C=O) MS *m/z* (rel. int.): 364 $[M]^+$ (0.3), 304.240 $[M-HOAc]^+$ (9) (calc. for $C_{20}H_{32}O_2$: 304.240), 289 (12), 223 (18), 205 (32), 195 (10), 177 (34), 109 (58), 81 (87), 69 (100); $[\alpha]_D^{24}$ +10 ($CHCl_3$; *c* 0.26).

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