Available online at www.sciencedirect.com
SCIENCE DIRECT®
PERGAMON
Phytochemistry 64 (2003) 631–635
PHYTOCHEMISTRY
www.elsevier.com/locate/phytochem

Secondary metabolites from *Cedrelopsis grevei* (Ptaeroxylaceae)

Dulcie A. Mulholland[a,*], Dashnie Naidoo[a], Milijaona Randrianarivelojosia[a,b], Peter K. Cheplogoi[a], Philip H. Coombes[a]

[a]*Natural Products Research Group, School of Pure and Applied Chemistry, University of Natal, Durban, 4041, South Africa*
[b]*Malaria Research Group, BP 1274- Antananarivo (101)- Institut Pasteur de Madagascar, Madagascar*

Received 16 January 2003; received in revised form 5 May 2003

Dedicated to the memory of Professor Jeffrey B. Harborne

Abstract

From the hexane extract of the stem bark of *Cedrelopsis grevei* (Ptaeroxylaceae) was isolated the triterpenoid derivative, cedashnine, and the quassinoid, cedphiline, along with cedmiline, scoparone, β-amyrin and sitosteryl glucoside.

Keywords: Ptaeroxylaceae; *Cedrelopsis grevei*; Triterpenoid derivative; Quassinoid; Cedmiline; Cedashnine; Cedpetine; Scoparone; β-Amyrin; Sitosteryl glucoside

1. Introduction

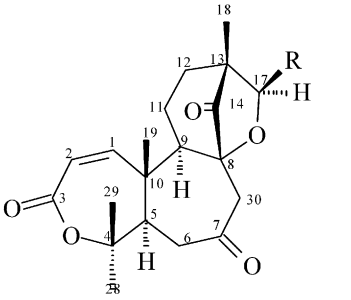
The secondary metabolites isolated from the Madagascan species *Cedrelopsis grevei* (Ptaeroxylaceae) vary greatly from specimen to specimen investigated. We have recently reported the isolation of two limonoid derivatives, cedmiline and cedmilinol from the bark of a specimen collected at Ankarafantsika in the wetter north of Madagascar (Mulholland et al., 1999a). The bark and wood of specimens collected in the drier south have yielded a range of coumarins and chromones including cedrelopsin, greveichromenol, greveiglycol, heteropeucenin, peucenin, alloptaeroxylin, ptaeroxylinol, ptaeroglycol, ptaeroxylin, (Mulholland et al., 1999b; Dean et al.,1967; Dean and Robinson, 1971; Dean and Taylor, 1966; Eshiett and Taylor, 1968; McCabe et al., 1967; Schulte et al., 1973), cedrecoumarins A and B, (Mulholland et al., 2002) whereas the fruit contains prenylated chalcones and flavanones (Koorbanally et al., 2003). A further specimen (08-99/MJ.MDul,TAN) was collected during the flowering period from Ankarafantsika in an attempt to isolate more of the limonoid derivatives. However, cedmiline (**1**), a related hexanortriterpenoid, cedashnine (**2**), a quassinoid, cedphiline (**3**), the known coumarin, scoparone (**4**), and the common phytosterols, β-amyrin and sitosteryl glucoside were isolated.

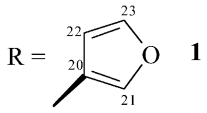
2. Results and discussion

The hexane extract of the stem bark of *Cedrelopsis grevei* yielded the limonoid derivative, cedmiline (**1**), isolated previously from this source (Mulholland et al., 1999a) and the related compound, cedashnine (**2**). Cedashnine **2** differs from cedmiline **3** only in the structure of the side chain. In cedmiline **3**, the side chain occurs as a furan ring, but in cedashnine **2**, a 21-hydroxy-23,21-butenolide ring is present. Cedashnine **2** is a hexanortriterpenoid with a molecular formula of $C_{24}H_{28}O_8$. The IR spectrum showed bands at 3381 cm^{-1} (OH stretch), 1710 and 1756 cm^{-1} (C=O stretch). The presence of a ring A α,β-unsaturated lactone was indicated by a pair of doublets at δ6.37 (H-1) and δ5.90 (H-2, $J=12.8$ Hz) and resonances at δ153.9, δ118.4 and δ167.5 ascribable to C-1, C-2 and C-3 respectively. The C-4 oxygenated quaternary carbon resonance occurred at δ84.8. Ring B was expanded incorporating C-30 as previously reported for cedmiline **3** and cedmilinol (Mulholland et al., 1999a). This was indicated by the chemical shifts of C-7 (δ209.0) and the diastereotopic H-30 protons (δ3.57 and δ2.46 ABq, $J=12.3$ Hz).

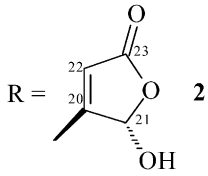
* Corresponding author. Tel.: +27 31 260 1108; fax: +27 31 260 3091.
E-mail address: mulholld@nu.ac.za (D.A. Mulholland).

0031-9422/03/$ - see front matter © 2003 Elsevier Ltd. All rights reserved.
doi:10.1016/S0031-9422(03)00342-X

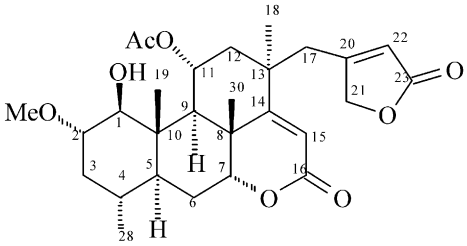




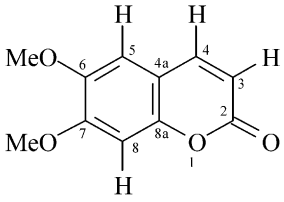
1



2



3



4

Resonances ascribed to H-5 and H-6α and β each occurred as double doublets at δ3.09 ($J=4.0$, 7.8), δ2,78 ($J=4.0$, 17.0) and δ2.46 ($J=7.8$, 17.0) respectively. The COSY spectrum showed coupling between the H-9 resonance (δ1.99) and the two H-11 resonances which were, in turn, seen to be coupled to the two H-12 resonances. The H-17 resonance occurred as a singlet at δ5.25. NOESY correlations between H-17 and H-9, H-12α and H-18 indicated that H-17 was in the α-orientation as was shown to be the case with cedmiline **3**. The ketone carbonyl resonance at δ212.3 showed HMBC correlations with H-17, 3H-18 and H-30β and thus was placed at C-14. The chemical shift of δ82.7 for C-8, as in cedmiline **3**, confirmed a C-17, C-8 ether linkage. Thus the basic tetracyclic structure of cedashnine **2** was confirmed to be the same as in cedmiline **3**. However, no resonances ascribable to a furan ring were present. Subtracting the number of atoms and double bond equivalents required for the tetracyclic structure, left $C_4H_3O_3$ and three double bond equivalents for the sidechain which could be assigned to a 21-hydroxy-23,21-butenolide ring. Double bond carbon resonances were seen at δ120.2 (C-20) and δ154.0 (C-22), a lactone carbonyl carbon at δ167.1 (C-23) and a hemiacetal carbon resonance at δ98.0 (C-21). The HSQC spectrum enabled the assignment of singlets at δ6.25 and δ6.10 to H-21 and H-22 respectively. The fact that the COSY spectrum showed no correlation between the two proton singlets and the HMBC spectrum showed correlations between both C-22 and C-21 and H-17 confirmed the above assignments. It was surprising that only one epimer was present for this compound. Usually in compounds of this type (Cheplogoi and Mulholland, 2003) some resonances are paired in the ^1H and ^{13}C NMR spectra because of the hemiacetal existing as a pair of C-21 epimers. A model was constructed to try to explain this observation. It was seen that hydrogen bonding can occur between the hydroxyl group proton at C-21 and the oxygen of the 8,17-ether if the hydroxyl group is α-orientated. Supporting evidence for this was a correlation observed in the NOESY spectrum between H-21 (which would have to be β) and the 3H-18 resonance. This was shown to be possible from the model. Thus an *S* configuration would occur at C-21. Thus structure (**2**) is proposed for cedashnine and is supported by HMBC and NOESY correlations as given in Table 1.

HRMS of cedphiline (**3**), showed a molecular ion at *m/z* 502.25593 indicating a formula of $C_{28}H_{38}O_8$. A peak at *m/z* 442 indicated the loss of an acetic acid molecule indicating the presence of an acetate group. The IR spectrum showed a hydroxyl stretch band (3500 cm^{-1}) and carbonyl absorptions at 1745 and 1719 cm^{-1}. The ^{13}C NMR spectrum showed the presence of 28 carbon atoms including two for an acetate group and one for a methoxyl group and thus indicated the presence of a C_{25} quassinoid of type D (Polonsky, 1985). A conspicuous pair of doublets at δ2.59 and 2.64 ($J=13.7$ Hz) were assigned to two H-17 protons. These protons showed HMBC correlations to C-20 (δ 164.2, C), C-21 (δ 74.5, CH_2) and C-22 (δ 120.1, CH) of a butenolide ring. Resonances at δ4.73 (2H) and δ5.92 (*s*, 1H) were assigned to 2H-21 and H-22. The resonance at δ173.1 showed HMBC correlations with 2H-21 and H-22 and

was assigned to C-23. The methyl group three proton singlets in the ^{1}H NMR spectrum were assigned to 3H-19 (δ_H 1.00), 3H-18 (δ_H 1.32) and 3H-30 (δ_H 1.34). The following HMBC correlations were observed: the 3H-19 resonance to C-1 (δ_C 81.0) and C-9 (δ_C 53.8), the 3H-30 resonance to C-7 (δ_C 78.8) and C-9 (δ_C 53.8) and the 3H-18 resonance to C-17 (δ_C 42.5). The methyl group proton doublet at δ_H 0.93 (J = 6.4 Hz) showed HMBC correlations to C-3 (δ_C 37.5), C-4 (δ_C 29.1) and C-5 (δ_C 44.2) and was assigned to 3H-28. The C-28 resonance appeared at δ_C 20.0. The carbonyl carbon resonance at δ_C 164.9 was assigned to C-16 of the ring D lactone. The C-16 resonance showed HMBC correlations to the H-15 resonance at δ_H 5.83. The H-7 and H-9 resonances appeared at δ_H 4.14 and 1.89 respectively in the ^{1}H NMR spectrum. The H-9 resonance (δ_H 1.89) showed HMBC correlations with C-1 (δ_C 81.0), C-5 (δ_C 44.2), C-7 (δ_C 78.8), C-8 (δ_C 39.1), C-10 (δ_C 42.1), C-11 (δ_C 70.7), C-14 (δ_C 172.4), C-19 (δ_C 11.8), and C-30 (δ_C 23.0). The H-5 and H-1 resonances appeared at δ_H 1.24 and 3.08 respectively. The H-1 resonance (δ_H 3.08) was superimposed with the H-2 resonance at δ_H 3.08 and this created problems in assigning the stereochemistry of H-1 and H-2. The resonances at δ_C 81.0, 80.6 and δ_C 56.6 were assigned to C-1, C-2 and the methoxyl group carbon respectively by use of the HSQC spectrum. The methoxyl group proton resonance showed HMBC correlation to C-2 (δ_C 80.6), which confirmed that the methoxyl group was attached at C-2. On biosynthetic grounds, 3H-19 and 3H-30 are β-orientated and H-5, H-9, 3H-18 and 3H-28 are α-orientated. The H-1/H-2 superimposed resonance showed NOESY correlations with 3H-19, H-4, H-5, H-9, the methoxyl group proton resonance and a very weak correlation with 3H-28. In order to distinguish between NOESY correlations with H-2 and H-3, the compound was acetylated. Although the NOESY spectrum of the acetylated product was weak due to the small amount of material available for acetylation, it was clear that the H-1 resonance had shifted to become superimposed with the H-21 correlation at δ_H 4.73 and showed NOESY correlations with H-5 and H-9 confirming that H-1 was α and hence the hydroxyl group at C-1, β. Upon acetylation of **3**, the H-2 resonance moved under the methoxyl group proton resonance at δ3.33, but a strong NOESY correlation could be seen with the 3H-19 and H-4 resonances confirming β-stereochemistry for H-2. The H-6 resonance at δ_H 1.82 showed NOESY correlations with H-4 and 3H-19, which indicated a β-orientation for this H-6 proton. The C-6 resonance appeared at δ_C 25.4 and the remaining H-6α resonance was shown to occur at δ_H 2.05 by use of the

Table 1
NMR spectral data for cedashnine (**2**)

C	δ^{13}C / ppm (CD_3OD)	δ^1H / ppm (CD_3OD)	HMBC (C→H)	COSY	NOESY
1	154.0 (CH)	6.37 (*d*, *J* = 12.9 Hz)	19	2	2, 11α, 19
2	118.4 (CH)	5.90 (*d*, *J* = 12.9 Hz)		1	1
3	167.5 (C)	–			
4	84.8 (C)	–	2, 28, 29		
5	51.9 (CH)	3.09 (*dd*, *J* = 4.0, 7.8 Hz)	1, 19, 28, 29	6α, 6β	6α, 9, 28, 30α
6	46.2 (CH_2)	α) 2.78 (*dd*, *J* = 4.0, 17.0 Hz)	30β	5, 6β	5, 6β, 28
		β) 2.46 (*dd*, *J* = 7.8, 17.0 Hz)		5, 6α	6α, 19, 29
7	209.0 (C)	–	6β, 30α, 30β		
8	82.7 (C)	–	30α, 30β		
9	64.4 (CH)	1.99 (*m*)	19, 30β	11α	5, 11α, 17
10	48.5 (C)	–	2, 19		
11	21.3 (CH_2)	α) 1.88 (*m*)	12α	9, 11β, 12α, 12β	1, 9, 12α
		β) 2.06 (*m*)		11α, 12β	12β, 19
12	41.4 (CH_2)	α) 2.06 (*m*)	17, 18	11α, 12β	11α, 17, 18
		β) 1.60 (*m*)		11α, 11β, 12α	11β, 18
13	51.1 (C)	–	17, 18		
14	212.3 (C)	–	17, 18, 30β		
17	79.6 (CH)	5.25 (*s*)	18		9, 12α, 18, 22
18	13.6 (CH_3)	0.97 (*s*)			12α, 12β, 17, 21, 22
19	18.6 (CH_3)	1.22 (*s*)	1		1, 6β, 11β, 29, 30β
20	120.2 (C)	–			
21	98.0 (CH)	6.25 (*s*)	17		18, 30β
22	154.0 (CH)	6.10 (*s*)	17		17, 18
23	167.1 (C)	–			
28	31.1 (CH_3)	1.43 (*s*)	29		5, 6α, 29
29	19.8 (CH_3)	1.53 (*s*)	28		6β, 19, 28
30	44.6 (CH_2)	α) 3.57 (*d*, *J* = 12.3 Hz)		30β	5, 30β
		β) 2.46 (*d*, *J* = 12.3 Hz)		30α	21, 30α

HSQC spectrum. Both the H-6α and H-6β resonances were seen to be coupled in the COSY spectrum to H-5 and H-7. The two H-3 proton resonances appeared at δ_H 0.90 and 2.08 in the ^{1}H NMR spectrum The acetate group proton resonance appeared at δ_H 1.94 in the ^{1}H NMR spectrum of **3**. The carbonyl carbon resonance of the acetate group appeared at δ_C 170.8 and showed HMBC correlations with H-11 at δ_H 5.64, which indicated that the acetate group was attached at C-11 (δ_C 70.7). The H-11 resonance showed a NOESY correlation to 3H-19, which suggested a β-orientation for this H-11 proton, leaving the acetate group with an α-orientation. The H-11 resonance also showed HMBC correlations with C-9 (δ_C 53.8), C-12 (δ_C 41.5) and C-13 (δ_C 39.6). The two H-12 resonances appeared as a doublet (J = 16.3 Hz) at δ_H 2.00 and a double doublet (J = 16.3, 5.3 Hz) at δ_H 2.42. It was not possible to distinguish between the H-12α and H-12β resonances as both H-12 resonances showed a NOESY correlation with H-11 and the resonance at δ_H 2.42 showed a NOESY correlation with the superimposed 3H-18/3H-30 resonance. All other NOESY correlations agreed with a model of cedphiline (**3**).

The known compounds scoparone (**4**), and β-amyrin were also isolated from the hexane extract and sitosteryl glucoside was isolated from the ethyl acetate extract. These compounds were identified using NMR spectroscopy and structures confirmed by comparison against literature values (Matida et al., 1996; Ahmad, 1994; Duddeck and Kaiser, 1982)

This is the first report of the isolation of a quassinoid from outside the Simaroubaceae family. It is interesting that both limonoids and quassinoids have only been found to occur together only in the *Cedrelopsis* genus of the Ptaeroxylaceae family and the *Harrisonia* genus of the Simaroubaceae. The similarity between the highly rearranged limonoids from *Cedrelopsis* and *Harrisonia* also supports a close link between the Ptaeroxylaceae and the *Harrisonia* genus of the Simaroubaceae. We have previously noted close similarities between compounds isolated from the Cneoraceae and Ptaeroxylaceae families (Mulholland and Mahomed, 2000)

Table 2
NMR spectral data for cedphiline (**3**)

C	δ^{13}C / ppm ($CDCl_3$)	δ^1H / ppm ($CDCl_3$)	HMBC (C→H)	COSY	NOESY
1	81.0 (CH)	3.08[a]	9, 19	2	5, 9, OMe
2	80.6 (CH)	3.08[a]	1, 3α, OMe	1, 3β, 3α	4, 19, OMe
3	37.5 (CH_2)	α) 0.90 (*m*)	28	2, 3β, 4	3β
		β) 2.08 (m)		2, 3α	2, 3α, 28, OMe
4	29.1 (CH)	1.38 (*m*)	28	3α	2, 3β, 19, 28
5	44.2 (CH)	1.24 (*m*)	9, 19, 28	6α, 6β	1, 9, 28
6	25.4 (CH_2)	α) 2.08 (*m*)		5, 6α, 7	6β, 7, 28
		β) 1.82 (*m*)		5, 6β, 7	4, 6α, 7, 19, 30
7	78.8 (CH)	4.14 (*m*)	9, 30	6β, 6α	6α, 6β, 30
8	39.1 (C)	–	9, 15, 30		
9	53.8 (CH)	1.89 (*d*, J = 5.6 Hz)	1, 7, 11, 12β, 19, 30	11	1, 5
10	42.1 (C)	–	9, 19		
11	70.7 (CH)	5.64 (*m*)	9, 12β	9, 12β, 12α	12α, 12β, 19
12	41.5 (CH_2)	α) 2.00 (*d*, J = 16.3 Hz)[b]	11, 17a, 17b, 18	11, 12β	11, 12β
		β) 2.42 (*dd*, J = 16.3, 5.3 Hz)[b]		11, 12α	11, 12α, 18/30
13	39.6 (C)	–	11, 12β, 12α, 17a, 17b, 18		
14	172.4 (C)	–	9, 12β, 15, 17b, 18, 30		
15	116.4 (CH)	5.83 (*s*)			17a, 18, 21
16	164.9 (C)	–	15		
17	42.5 (CH_2)	a) 2.59 (*d*, J = 13.7 Hz)	12α, 18	17b	15, 17b, 18, 21, 22
		b) 2.64 (*d*, J = 13.7 Hz)		17a	17a, 18, 21, 22
18	31.2 (CH_3)	1.32 (*s*)	12β, 12α, 17a, 17b		12α, 15, 17a, 17b, 21, 22
19	11.8 (CH_3)	1.00 (*s*)	1, 9		2, 4, 6β, 11, 30
20	164.2 (C)	–	17a, 17b, 21, 22		
21	74.5 (CH_2)	4.73 (2H) (*d*, J = 1.1 Hz)	17a, 17b, 22		15, 17a, 17b, 18/30
22	120.1 (CH)	5.92 (*s*)	17a, 17b, 21		17a, 17b, 18/30
23	173.1 (C)	–	21, 22		
28	20.0 (CH_3)	0.93 (*d*, J = 6.4 Hz)			4, 5, 6α
30	23.0 (CH_3)	1.34 (*s*)	7, 9		6β, 7, 19
Oac Me	21.8 (CH_3)	1.94 (*s*)			
OMe	56.6 (CH_3)	3.33 (*s*)			1, 2, 3β
OAc C=O	170.8 (C)	–	11, AcO Me		

[a] Resonances superimposed, NOESY correlations could be distinguished by examining the NOESY spectrum of an acetylated product.
[b] The H-12α and H-12β resonances may be interchanged. Both showed NOESY correlations with H-11 and one showed a correlation with the superimposed 3H-18, 3H-30 resonance.

3. Experimental

Stem bark of *Cedrelopsis grevei* Baill. (Ptaeroxylaceae) was collected from Ankarafantsika in the north-west forest of Madagascar and identified by Dr. M. Randrianarivelojosia and a voucher specimen retained (08-99/MJ.MDul,TAN). The dried, milled stem bark (1.7 kg) was extracted successively using a Soxhlet apparatus with hexane, ethyl acetate and methanol for 48 h with each solvent. The hexane extract (143 g) yielded, after cc over silica gel (Merck 9385) using 5 g of extract, β-amyrin (55 mg) and scoparone (**4**) (14 mg). A sample of 8 g of the ethyl acetate extract (39 g) was separated as above and yielded cedmiline (**1**), (50 mg), cedphiline (**3**), (45 mg), cedashnine (**2**), (25 mg) and sitosteryl β-D-glucopyranoside (21 mg). The ^{1}H NMR spectrum of the methanol extract indicated the presence of sugars only, so was not investigated further.

IR spectra were recorded with a Nicolet Impact 400 D spectrometer on sodium chloride plates and calibrated against an air background. HRMS were obtained using a Kratos High Resolution MS 9/50 spectrometer at the Cape Technikon. UV spectra were recorded with a Varian DMS 300 UV–visible spectrophotometer using dichloromethane as solvent. ^{1}H and ^{13}C NMR spectra were recorded on a Varian Unity Inova 400 MHz NMR spectrometer. Optical rotations were measured at room temperature using either a Perkin Elmer 241 Polarimeter or an Optical Activity AA-5 Polarimeter together with a series A2 stainless steel (4×200 mm) unjacketed flow tube.

Cedashnine (**2**): white crystalline (25 mg); m.p. 220–221 °C; HRMS: 444.17759 ($C_{24}H_{28}O_8$ req. 444.17842), 426.16951(M^+-H_2O), 316.16656, 277.07193, 258.12538, 175.10432, 121.06497, 108.05742 (100%); IR: ν_{max}(NaCl): 3381, 2861, 1756, 1710 cm^{-1}; $[\alpha]_D$ + 15.38 (*c* 0.26, CH_3OH). For NMR spectral data, see Table 1.

Cedphiline (**3**): white crystalline (45 mg); m.p.160–161 °C; HRMS: 502.25593 ($C_{28}H_{38}O_8$ req. 502.25667), 85.06565 (100%), 119.08579 (19.48%), 345.20736 (18.59%), 410.2087 (27.90%), 442.23434 (M^+–CH_3COOH) (21.08%), 459.23942 (M^+–$CH_3C{=}O$) (7.61%); IR: ν_{max}(NaCl): 3500, 2917, 2855, 1745, 1719 cm^{-1}; $[\alpha]_D$ −43.97 (*c* 0.348, CH_2Cl_2). For NMR spectral data, see Table 2.

Acknowledgements

This research was funded by the University of Natal Research Fund and the Foundation for Research and Development. We gratefully acknowledge the Wellcome Trust Equipment grant number 052451 for the provision of the 400 MHz NMR spectrometer. We are grateful to Mr. Dilip Jagjivan and Dr. P. Boshoff for running NMR and mass spectra and Dr. Harison Rabarison and Mr. Romain for their assistance in obtaining and identifying plant material.

References

Ahmad, V.U., 1994. Handbook of Natural Products Data, volume 2, Pentacyclic Triterpenoids. Elsevier Science B.V., London. pp. 21-22.

Cheplogoi, P.K., Mulholland, D.A., 2003. Tetranortriterpenoid derivatives from *Turraea parvifolia* (Meliaceae). Phytochemistry 62, 1173–1178.

Dean, F.M., Parton, B., Somvichien, N., Taylor, D.A.H., 1967. Chromones, containing an oxepin ring, from *Ptaeroxylon obliquum*. Tetrahedron Letters 36, 3459–3464.

Dean, F.M., Robinson, M.L., 1971. Heartwood chromones of *Cedrelopsis grevei*. Phytochemistry 10, 3221–3227.

Dean, F.M., Taylor, D.A.H., 1966. Extractives from East African timbers. II. *Ptaeroxylon obliquum*. J. Chem. Soc. (C) 114–116.

Duddeck, H., Kaiser, M., 1982. ^{13}NMR Spectroscopy of Coumarin Derivatives. Organic Magnetic Resonance 20, 55–73.

Eshiett, I.T., Taylor, D.A.H., 1968. The isolation and structure elucidation of some derivatives of dimethylallylcoumarin, chromone, quinoline, and phenol from *Fagara* species and from *Cedrelopsis grevei*. J. Chem. Soc. (C) 481–484.

Koorbanally, N.A., Randrianarivelojosia, M., Mulholland, D.A., Quarles van Ufford, L., van den Berg, A.J.J., 2003. Extractives from the seed of *Cedrelopsis grevei*. Phytochemistry 62, 1225–1226.

Matida, A.K., Rossi, M.H., Blumenthal, E.E.A., Schuquel, I.T.A., Malheiros, A., Vidotti, G.J., 1996. 3-β-*O*-β-D-Glucopyranosylsitosterol in species of Labiatae, Verbenaceae and Apocynaceae. Ann. Assoc. Bras. Quim. 45, 147–151.

McCabe, P.H., McCrindle, R., Murray, R.D.H., 1967. Constituents of sneezewood, *Ptaeroxylon obliquum*. I. Chromones. J. Chem. Soc. (C) 145–151.

Mulholland, D.A., Mahomed, H., Randrianarivelojosia, M., Lavaud, C., Massiot, G., Nuzillard, J., 1999a. Limonoid derivatives from *Cedrelopsis grevei*. Tetrahedron 55, 11547–11552.

Mulholland, D.A., Kotsos, M., Mahomed, H.A., Randrianarivelojosia, M., 1999b. The chemistry of the Ptaeroxylaceae. Nig. J. Nat. Prod. Med. 3, 13–16.

Mulholland, D.A., Kotsos, M., Mahomed, H.A., Koorbanally, N.A., Randrianarivelojosia, M., van Ufford, L.Q., van den Berg, A.A.J., 2002. Coumarins from *Cedrelopsis grevei* (Ptaeroxylaceae). Phytochemistry 61, 919–922.

Mulholland, D.A., Mahomed, H., 2000. Isolation of Cneorubin X, an unusual diterpenoid from *Ptaeroxylon obliquum* (Ptaeroxylaceae). Biochemical Systematics and Ecology 28, 713–716.

Polonsky, J., 1985. Quassinoid Bitter Principles II. Progress in the Chemistry of Organic Natural Products 47, 221–264.

Schulte, K.E., Ruecker, G., Klewe, U., 1973. Components of medicinal plants. XXVIII. Some constituents of the bark of *Cedrelopsis grevei*. Arch. Pharm. (Weinheim, Ger.) 306, 857–865.