Available online at www.sciencedirect.com
ScienceDirect
Phytochemistry 69 (2008) 553–557
PHYTOCHEMISTRY
www.elsevier.com/locate/phytochem

Furoquinoline alkaloids of *Ertela* (*Monnieria*) *trifolia* (L.) Kuntze from the Suriname rainforest

Shugeng Cao [a], Adnan J. Al-Rehaily [b], Peggy Brodie [a], Jan H. Wisse [c], Etienne Moniz [c], Stan Malone [d], David G.I. Kingston [a,*]

[a] *Department of Chemistry, M/C 0212, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, United States*
[b] *Department of Pharmacognosy, College of Pharmacy, King Saud University, Riyadh 11451, Saudi Arabia*
[c] *Bedrijf Geneesmiddelen Voorziening Suriname, Commissaris Roblesweg 156, Geyersvlijt, Suriname*
[d] *Conservation International Suriname, Burenstraat 7, Paramaribo, Suriname*

Received 24 May 2007; received in revised form 29 June 2007
Available online 21 September 2007

Abstract

7-(2'-Hydroxy-3'-chloroprenyloxy)-4,8-dimethoxyfuroquinoline (**1**) and 6-(2'-hydroxy-3'-chloroprenyloxy)-4,7-dimethoxyfuroquinoline (**2**), together with ten known compounds, have been isolated from the aerial parts of *Ertela* (*Monnieria*) *trifolia* (L.) Kuntze. All the isolates were tested for antiproliferative activity against the A2780 human ovarian cancer cell line.

Keywords: *Ertela trifolia*; *Monnieria trifolia*; Rutaceae; Furoquinoline alkaloids; Acridone alkaloids; Furofuran lignans; NMR; Cytotoxicity

1. Introduction

In our continuing search for bioactive molecules from the Suriname and Madagascar rainforests as part of an International Cooperative Biodiversity Group (ICBG) program (Cao et al., 2007), we obtained a methanol extract of the aerial parts of *Ertela trifolia* (L.) Kuntze (Rutaceae). This extract (BGVS 320017) showed antiproliferative activity against the A2780 human ovarian cancer cell line, with an IC_{50} value of 20 μg/mL. *E. trifolia* is also known as *Monnieria trifolia*, and it has been the subject of several previous phytochemical studies (Bhattacharyya and Serur, 1981, 1983; Bhattacharyya et al., 1984; Bulhoes and Da Mota e Silva, 1976; Cave et al., 1971; Fouraste et al., 1973; Keita et al., 1985; Moulis et al., 1981; Rouffiac et al., 1969). To the best of our knowledge, none of the *Monnieria* sp. have been investigated for their bioactivities. In the present communication, we describe the A2780 guided-separation of twelve compounds, the structure elucidation of the two new alkaloids 7-(2′-hydroxy-3′-chloroprenyloxy)-4,8-dimethoxyfuroquinoline (**1**) and 6-(2′-hydroxy-3′-chloroprenyloxy)-4,7-dimethoxyfuroquinoline (**2**), and the reassignment of the structure of a previously isolated compound as **13**.

2. Results and discussion

Compound **1** was obtained as pale yellow powder. The EIMS of **1** showed the presence of a molecular ion peak at *m/z* 366 $[M+1]^+$ corresponding to the molecular formula $C_{18}H_{20}ClNO_5$, together with a peak at *m/z* 368 (34% relative to the molecular ion peak) due to the ^{37}Cl isotope, which confirmed the presence of a chlorine atom. The UV spectrum exhibited absorptions at λ_{max} 249 nm and a broad band in the region 300–345 nm, typical of a furoquinoline alkaloid. The ^1H NMR spectrum of **1** showed

* Corresponding author. Tel.: +1 540 231 6570; fax: +1 540 231 3255.
E-mail address: dkingston@vt.edu (D.G.I. Kingston).

0031-9422/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.phytochem.2007.08.009

signals for two olefinic doublets, two methoxy groups, two methyl groups, one oxygenated methine, one oxygenated methylene, and two aromatic doublets. The ^{1}H and ^{13}C NMR spectroscopic data (Table 1) of **1** were similar to those of **3**, except for the C5 side chain at C-7. The HMBC correlations from H-5 (δ_H 7.95, *d*, $J = 9.3$ Hz) and 4-OMe (δ_H 4.43, *s*) to C-4 (δ_C 156.7), and 8-OMe (δ_H 3.94, *s*) to C-8 (δ_C 141.8), together with the ROESY correlations between H-2 (δ_H 8.00, *d*, $J = 2.8$ Hz) and H-3 (δ_H 7.45, *d*, $J = 2.8$ Hz), H-3 and 4-OMe, H-5 and H-6 (δ_H 7.44, *d*, $J = 9.3$ Hz), and H-6 and H_2-1′ (δ_H 4.49, *dd*, $J = 2.8$, 10.2 Hz; 4.14, *dd*, $J = 7.5$, 10.2 Hz) demonstrated that **1** was a 4,8-dimethoxyfuroquinoline alkaloid substituted at C-7 (Fig. 1). HMBC correlations were observed from 2′-OH (δ_H 5.77, *d*, $J = 6.1$ Hz) to C-1′ (δ_C 71.3), C-2′ (δ_C 75.9), and C-3′ (δ_C 73.0), and from H_3-5′ (δ_H 1.64, *s*) to C-2′, C-3′, and C-4′ (δ_C 27.9). Therefore, based on the EIMS spectrum of **1**, the functional group at C-3′ of the side chain at C-7 must be –Cl, and the substituent at C-7 was then established as 2′-hydroxy-3′-chloro-3′-methyl butoxy. Hence, the structure of **1** was determined as shown.

The EIMS of **2** also showed a molecular ion peak at *m/z* 366 $[M+1]^+$ corresponding to the molecular formula $C_{18}H_{20}ClNO_5$, together with a peak at *m/z* 368 (36% relative to the molecular ion peak) due to a ^{37}Cl isotope, which demonstrated that **2** and **1** were isomers. The ^{1}H NMR spectrum (Table 1) of **2** exhibited peaks for two olefinic

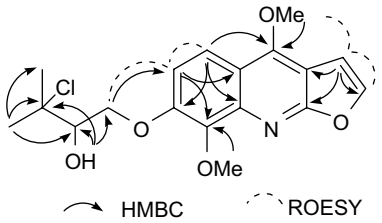


Fig. 1. Key HMBC and ROESY correlations for **1**.

doublets, two methoxy groups, two methyl groups, one oxygenated methine, one oxygenated methylene, and two aromatic singlets. In the HMBC spectrum, ^{3}J correlations from 4-OMe (δ_H 4.43, *s*) to C-4 (δ_C 155.0), 7-OMe (δ_H 3.93, *s*) to C-7 (δ_C 152.4), and H-5 (δ_H 7.49, *s*) to C-4 were observed, and in the ROESY spectrum, correlations between H-2 (δ_H 7.95, *d*, $J = 2.8$ Hz) and 4-OMe to H-3 (δ_H 7.42, *d*, $J = 2.8$ Hz), and 7-OMe and H-8 (δ 7.29, *s*) were exhibited. The ROESY correlation between H-5 and H_2-1′ (δ_H 4.40, *dd*, $J = 2.2$, 10.2 Hz; 4.06, *dd*, $J = 7.5$, 10.2 Hz) indicated that 2′-hydroxy-3′-chloro-3′-methyl butoxy was located at C-6. Hence, the structure of **2** was determined as 6-(2′-hydroxy-3′-chloroprenyloxy)-4,7-dimethoxyfuroquinoline (see Fig. 2).

Neither compound **1** nor **2** showed any optical rotation, suggesting that both were racemic. This observation, cou-

Table 1
^{1}H and ^{13}C NMR spectroscopic data for compounds **1**, **2**, and **13** (DMSO-d_6)

No.	^{1}H[a]			No.	^{13}C[b]		
	1	**2**	**13**		**1**	**2**	**13**
2	8.00 *d* (2.8)	7.95 *d* (2.8)	7.90 *d* (2.6)	2	143.8	143.0	143.6
3	7.45 *d* (2.8)	7.42 *d* (2.8)	7.38 *d* (2.8)	3	105.4	105.2	105.9
3a				3a	114.2	101.8	102.5
4				4	156.7	155.0	155.7
4a				4a	101.8	112.0	112.8
5	7.95 *d* (9.3)	7.49 *s*	7.44 *s*	5	117.7	101.1	101.4
6	7.44 *d* (9.3)			6	113.8	146.6	147.7
7				7	151.4	152.4	153.1
8		7.29 *s*	7.26 *s*	8	141.8	106.6	107.0
8a				8a	140.8	141.8	142.3
9a				9a	163.8	162.5	163.1
4-OMe	4.43 *s*	4.43 *s*	4.40 *s*	4-OMe	59.2	59.2	59.8
7-OMe		3.93 *s*	3.90 *s*	7-OMe		55.5	56.2
8-OMe	3.94 *s*			8-OMe	60.8		
1′	4.49 *dd* (2.8, 10.2)	4.40 *dd* (2.2, 10.2)	4.30 *dd* (2.2, 10.2)	1′	71.3	70.2	71.6
	4.14 *dd* (7.5, 10.2)	4.06 *dd* (7.5, 10.2)	4.06 *dd* (7.5, 10.2)				
2′	3.91 *m*	3.92 *m*	3.92 *m*	2′	75.9	75.4	76.3
3′				3′	73.0	73.0	71.0
4′	1.59 *s*	1.60 *s*	1.12 *s*	4′	27.9	27.8	24.8
5′	1.64 *s*	1.64 *s*	1.16 *s*	5′	29.6	29.5	27.9
2′-OH	5.77 *d* (6.1)	5.78 *d* (6.3)	5.16 *d* (5.5)	2′-OH			
3′-OH			4.59 *s*				

[a] δ (ppm) 500 MHz; multiplicities; *J* values (Hz) in parentheses.
[b] δ (ppm) 125 MHz.

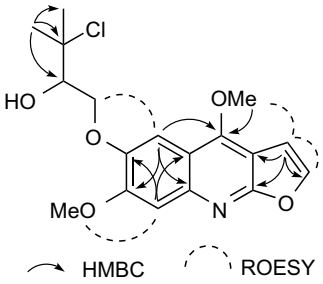
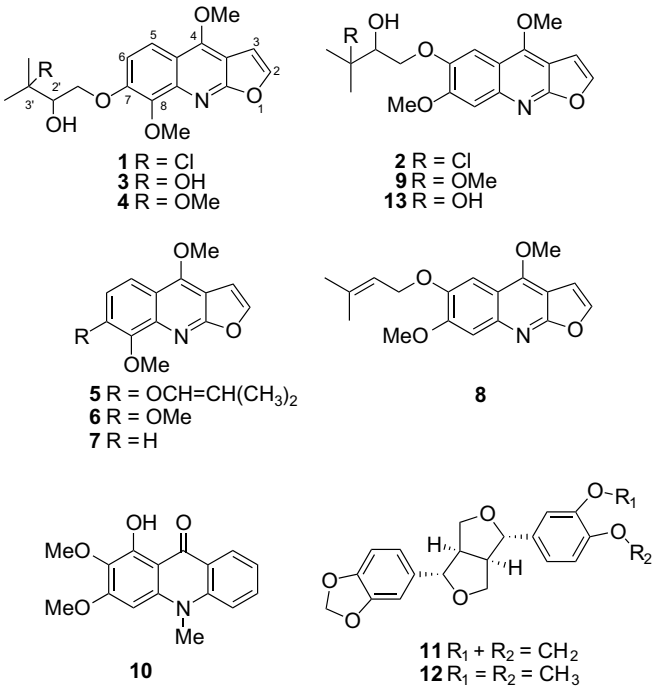


Fig. 2. Key HMBC and ROESY correlations for **2**.



pled with the fact that the isolation of chlorine-containing plant products is unusual, made it important to demonstrate that compounds **1** and **2** were not artefacts caused by ring opening of an epoxide with HCl. The crude extract was thus examined by LC-MS. A peak with the same retention time and molecular ion as compounds **1** and **2** was detectable in this crude extract, demonstrating that these compounds were present in the crude extract and were not an artifact of isolation. Since the extract was prepared by simple room temperature extraction of the plant material with methanol, and had never been treated with HCl, it is unlikely that hydrochlorination could have occurred at this stage, and the compounds are thus presumably genuine natural products. Although chlorinated prenyl groups are rare, they are not unknown. As one example *Toddalia asiatica*, also a member of the Rutaceae family, yielded the chlorinated prenyl derivative 5,7-dimethoxy-6-(3'-chloro-2'-hydroxy-3'-methylbutyl)coumarin (Sharma et al., 1981).

The structure of 6-(2'-hydroxy-3'-chloroprenyloxy)-4,7-dimethoxyfuroquinoline (**2**) was previously published under the name chlorodesnkolbisine (compound **AR5**, Al-Rehaily et al., 2003). A comparison of the NMR spectroscopic data of **2** with those of **AR5** indicated that the two compounds were different. A sample of **AR5** was then supplied by Dr. Al-Rehaily and investigated by MS and NMR spectroscopy. These data indicated that it was in fact nkolbisine (**13**) (Ayafor et al., 1982).

The structures of the ten known compounds isolated in this study were determined to be chaplophytin-B (**3**) (Ali et al., 2001), 7-(2'-hydroxy-3'-methoxy-prenyloxy)-4,8-dimethoxyfuroquinoline (**4**) (Akhmedzhanova et al., 1975), 7-isopentenyloxy-γ-fagarine (**5**) (Dreyer, 1969), skimmianine (**6**) (Chakravarty et al., 1999), 4,8-dimethoxyfuro[2,3-*b*]quinoline (**7**) (Ito et al., 2004), tecleanatalesine B (**8**) (Tarus et al., 2005), methylnkolbisine (**9**) (Al-Rehaily et al., 2003), 1-hydroxy-2,3-dimethoxy-10-methylacridin-9(10*H*)-one (**10**) (Bergenthal et al., 1979), sesamin (**11**) (Hsieh et al., 2005), and fargesin (**12**) (Brown et al., 2001) by comparison of their spectroscopic data with literature data.

All the isolates were tested against A2780 human ovarian cancer cell line. Compounds **1, 2**, **5**, **6, 8**, **9**, and **10** showed weak antiproliferative activity with IC_{50} values of 13, 9, 13, 13, 16, 14, 12 μg/mL, respectively.

3. Experimental

3.1. General

Optical rotations were recorded on a Perkin–Elmer 241 polarimeter. IR and UV spectra were measured on MIDAC M-series FTIR and Shimadzu UV-1201 spectrophotometers, respectively. NMR spectra were obtained on a JEOL Eclipse 500 and an Inova 400 spectrometer. The chemical shifts are given in δ (ppm), and coupling constants are reported in Hz. Mass spectra were obtained on a JEOL JMS-HX-110 instrument, in the positive ion mode. HPLC was performed on a Shimadzu LC-10AT instrument with a semi-preparative phenyl Varian Dynamax column (5 μm, 250 × 10 mm) and a preparative C_{18}Varian Dynamax column (8 μm, 250 × 21.4 mm). Finnigan LTQ LC/MS was also used for EIMS analysis of compounds **1**, **2**, and **13**.

3.2. Plant material

A collection of stems, twigs, leaves, and flowers of *E. trifolia* (L.) Kuntze (also known as *M. trifolia*) was made in late 2000 at Solan; its local name is: Kofimaka. Voucher specimens have been deposited at the National Herbarium of the University of Suriname, Paramaribo, Suriname.

3.3. Extraction and isolation

The plant samples were dried, ground, and extracted with MeOH to give extracts BGVS 320017. Extract BGVS 320017 (1.9 g, IC_{50} 20 μg/mL) was suspended in aqueous MeOH (MeOH–H_2O, 9:1, 100 mL) and extracted with hexanes (3 × 100 mL portions). The aqueous layer was then diluted to 70% MeOH with H_2O and extracted with CH_2Cl_2 (3 × 100 mL portions). The CH_2Cl_2 extract (896 mg) was active with an IC_{50} of 15 μg/mL, while both the hexane and aqueous MeOH extracts were inactive. The CH_2Cl_2 extract was subjected to open C_{18} cc (130 × 22 mm) using H_2O–MeOH–CH_2Cl_2 (80:20:0 to 0:100:0, then 0:80:20) to yield three fractions, I [80 mg, inactive], II [700 mg, IC_{50} 12 μg/mL], and III [100 mg, inactive]. Fraction II furnished 12 subfractions (A–L) after HPLC separation on a C_{18} column (MeOH/H_2O (6:4,v/v) in 30 min, then to MeOH in 10 min, 10 mL/min). Further separation of subfractions B–F and H–K was carried out by preparative Si gel TLC to afford 12 compounds. Subfraction B yielded compound **3** [1.2 mg, $CHCl_3$–MeOH (100:2), R_f 0.2]; subfraction C, **7** [1.2 mg, $CHCl_3$–MeOH (100:2), R_f 0.4] and **12** [0.6 mg, $CHCl_3$–MeOH (100:2), R_f 0.3]; subfraction D, **6** [0.6 mg, $CHCl_3$–MeOH (100:2), R_f 0.3]; subfraction E, **9** [0.8 mg, $CHCl_3$–MeOH (100:2), R_f 0.5] and **10** [1.1 mg, $CHCl_3$–MeOH (100:2), R_f 0.7]; subfraction F, **4** [1.1 mg, $CHCl_3$ (with 0.5% MeOH), R_f 0.15]; subfraction H, **2** [0.6 mg, $CHCl_3$–MeOH (100:2), R_f 0.5] and **11** [0.6 mg, $CHCl_3$–MeOH (100:2), R_f 0.2]; subfraction I, **1** [1 mg, $CHCl_3$–MeOH (100:1), R_f 0.3]; and subfractions J and K, **5** [1 mg, $CHCl_3$, R_f 0.1] and **8** [1 mg, $CHCl_3$, R_f 0.15].

3.3.1. 7-(2′-Hydroxy-3′-chloroprenyloxy)-4,8-dimethoxyfuroquinoline (*1*)

Light yellow powder. $[\alpha]_D^{20}$ 0 (*c*; 0.10 in MeOH); UV λ_{max} (MeOH) nm (log ε): 249 (4.68), broad band in region 300345 nm [320 (3.97)]; IR (film) υ_{max} cm^{-1} 2934, 1590, 1474, 1363, 1251, 1084, 1016; ^1H NMR (500 MHz, $CDCl_3$): 1.68 (3H, *s*, H_3-4′), 1.69 (3H, *s*, H_3-5′), 3.31 (1H, *d*, *J* = 4.0 Hz, 2′-OH), 4.02(1H, *m*, H-2′), 4.14 (3H, *s*, 8-OMe), 4.26 (1H, *dd*, *J* = 8, 10.2 Hz, H-1′), 4.45 (3H, *s*, 4-OMe), 4.56 (1H, *dd*, *J* = 3.2, 10.2 Hz, H-1′), 7.07 (1H, *d*, *J* = 2.8 Hz, H-3), 7.25 (1H, *d*, *J* = 9.2 Hz, H-6), 7.61 (1H, *d*, *J* = 2.8 Hz, H-2), 8.03 (1H, *d*, *J* = 9.2 Hz, H-5); ^1H (500 MHz, DMSO-d_6): and ^{13}C (125 MHz, DMSO-d_6) NMR: see Table 1; (+)-EIMS *m*/*z* (rel. int. %): 368 (34), 366 (100); HRFABMS *m*/*z* 366.1077 (calcd for $C_{18}H_{21}ClNO_5$, 366.1108).

3.3.2. 6-(2′-Hydroxy-3′-chloroprenyloxy)-4,7-dimethoxyfuroquinoline (*2*)

Light yellow powder. $[\alpha]_D^{20}$ 0 (*c*; 0.06 in MeOH); UV λ_{max} (MeOH) nm (log ε): 247 (4.57), broad band in region 300345 nm [320 (4.03)]; IR (film) υ_{max} cm^{-1}: 2935, 1617, 1499, 1375, 1255, 1093; ^1H NMR (500 MHz, $CDCl_3$): 1.72 (3H, *s*, H_3-4′), 1.73 (3H, *s*, H_3-5′), 3.00 (1H, *d*, *J* = 4.4 Hz, 2′-OH), 4.00(3 H, *s*, 7-OMe), 4.14 (1H, *m*, H-2′), 4.20 (1H, *dd*, *J* = 7.6, 10.2 Hz, H-1′), 4.45(3H, *s*, 4-OMe), 4.49 (1H, *dd*, *J* = 2.4, 10.2 Hz, H-1′), 7.05 (1H, *d*, *J* = 2.8 Hz, H-3), 7.34 (1H, *s*, H-8), 7.57 (1H, *s*, H-5), 7.58 (1H, *d*, *J* = 2.8 Hz, H-2); ^1H (500 MHz, DMSO-d_6): and ^{13}C (125 MHz, DMSO-d_6) NMR: see Table 1; (+)-EIMS *m*/*z* (rel. int. %): 368 (36), 366 (100); HRFABMS *m*/*z* 366.1077 (calcd for $C_{18}H_{21}ClNO_5$, 366.1108).

3.4. Antiproliferative Bioassays

The A2780 ovarian cancer cell line assay was performed on compounds **1**–**13** at Virginia Polytechnic Institute and State University as previously described (Cao et al., 2007). The A2780 cell line is a drug – sensitive human ovarian cancer cell line (Louie et al., 1985).

Acknowledgements

This project was supported by the Fogarty International Center, the National Cancer Institute, the National Science Foundation, the National Heart, Lung and Blood Institute, the National Institute of Mental Health, the Office of Dietary Supplements, and the Office of the Director of NIH, under Cooperative Agreement U01 TW000313 with the International Cooperative Biodiversity Groups, and this support is gratefully acknowledged. We thank Mr. B. Bebout for obtaining the mass spectra and Mr. T. Glass for assistance with the NMR spectra.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.phytochem.2007.08.009.

References

Akhmedzhanova, V.I., Bessonova, I.A., Yunusov, S.Y., 1975. Methylevoxine, a new alkaloid from Haplophyllum perforatum. Khim. Prir. Soedin. 11 (2), 272.

Ali, M.S., Pervez, M.K., Saleem, M., Tareen, R.B., 2001. Haplophytin-A and B: the alkaloidal constituents of *Haplophyllum acutifolium*. Phytochemistry 57, 1277–1280.

Al-Rehaily, A.J., Ahmad, M.S., Muhammad, I., Al-Thukair, A.A., Perzanowski, H.P., 2003. Furoquinoline alkaloids from Teclea nobilis. Phytochemistry 64, 1405–1411.

Ayafor, J.F., Sondengam, B.L., Bilon, A.N., Tsamo, E., Kimbu, S.F., Okogun, J.I., 1982. Furoquinoline alkaloids of Teclea ouabanguiensis. J. Nat. Prod. 45, 714–717.

Bergenthal, D., Mester, I., Rózsa, Zs., Reisch, J., 1979. ^{13} C NMR-Spektren einiger acridon-alkaloide. Phytochemistry 18, 161–163.

Bhattacharyya, J., Serur, L.M., 1981. Structures of montrifoline and delbine: two new furoquinoline alkaloids from *Monnieria trifolia* L. Heterocycles 16, 371–374.

Bhattacharyya, J., Serur, L.M., 1983. The minor alkaloids of *Monnieria trifolia* L. Heterocycles 20, 1063–1066.

Bhattacharyya, J., Serur, L.M., Cheriyan, U.O., 1984. Isolation of the alkaloids of *Monnieria trifolia*. J. Nat. Prod. 47, 379–381.

Brown, R.C.D., Bataille, C.J.R., Bruton, G., Hinks, J.D., Swain, N.A., 2001. C-H insertion approach to the synthesis of endo,exo-furofuranones: synthesis of (±)-asarinin, (±)-epimagnolin A, and (±)-fargesin. J. Org. Chem. 66, 6719–6728.

Bulhoes, G. de C.C., Da Mota e Silva, A., 1976. Phytochemical screening of plants native to northeastern Brazil III. An. Fac. Farm., Univ. Federal Pernambuco 15, 45–50.

Cao, S., Brodie, P.J., Miller, J.S., Randrianaivo, R., Ratovoson, F., Birkinshaw, C., Andriantsiferana, R., Rasamison, V.E., Kingston, D.G.I., 2007. Antiproliferative xanthones of *Terminalia calcicola* from the madagascar rain forest. J. Nat. Prod. 70, 679–681.

Cave, A., Ramos de Souza, J.I., Paris, R.R., 1971. Brazilian Rutaceae, *Monnieria trifolia* isolation of an alkaloid identified as arborinine. Plantes Med. Phytother. 5, 327–329.

Chakravarty, A.K., Sarkar, T., Masuda, K., Shiojima, K., 1999. Carbazole alkaloids from roots of *Glycosmis arborea*. Phytochemistry 50, 1263–1266.

Dreyer, D.L., 1969. Coumarins and alkaloids of the Genus *Ptelea*. Phytochemistry 8, 1013–1020.

Fouraste, I., Gleye, J., Stanislas, E., 1973. Alkaloids of the leaves of *Monnieria trifolia*. Plantes Med. Phytother. 7, 216–224.

Hsieh, T.-J., Lu, L.-H., Su, C.-C., 2005. NMR spectroscopic, mass spectroscopic, X-ray crystallographic, and theoretical studies of molecular mechanics of natural products: farformolide B and sesamin. Biophys. Chem. 114, 13–20.

Ito, C., Itoigawa, M., Sato, A., Hasan, C.M., Rashid, M.A., Tokuda, H., Mukainaka, T., Nishino, H., Furukawa, H., 2004. Chemical constituents of *Glycosmis arborea*: three new carbazole alkaloids and their biological activity. J. Nat. Prod. 67, 1488–1491.

Keita, A., Gleye, J., Stanislas, E., Fouraste, I., 1985. C-Glycosylflavones from *Monnieria trifolia*. J. Nat. Prod. 48, 675–676.

Louie, K.G., Behrens, B.C., Kinsella, T.J., Hamilton, T.C., Grotzinger, K.R., McKoy, W.M., Winker, M.A., Ozols, R.F., 1985. Radiation survival parameters of antineoplastic drug-sensitive and -resistant human ovarian cancer cell lines and their modification by buthionine sulfoximine. Cancer Res. 45, 2110–2115.

Moulis, C., Gleye, J., Fouraste, I., Stanislas, E., 1981. New furoquinolines from *Monnieria trifolia*. Planta Med. 42, 400–402.

Rouffiac, R., Fouraste, I., Stanislas, E., 1969. Alkaloids of *Monnieria trifolia* 1. Characterization of skimmianine. Planta Med. 17, 361–365.

Sharma, P.N., Shoeb, A., Kapil, R.S., Popli, S.P., 1981. Chemical constituents of *Toddalia asiatica*. Indian J. Chem. 20B, 936–937.

Tarus, P.K., Coombes, P.H., Crouch, N.R., Mulholland, D.A., Moodley, B., 2005. Furoquinoline alkaloids from the southern African Rutaceae *Teclea natalensis*. Phytochemistry 66, 703–706.