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SESQUITERPENES AND ALKALOIDS FROM *CLEISTOPHOLIS PATENS**

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Key Word Index—*Cleistopholis patens*; Annonaceae; sesquiterpenes; methyl-(−)-(*trans*)-(*trans*)-10,11-dihydroxyfarnesoate; methyl-(+)-(*trans*)-10-hydroxy-6,11-cyclofarnes-7(14)-enoate; aza-polycyclic alkaloids, onychine, cleistopholine; naphthyridine alkaloids; eupolauridine; eupolauridine-N-oxides.

Abstract—The root bark of *Cleistopholis patens* collected in Ghana yielded two sesquiterpenes and five alkaloids. The sesquiterpenes have been characterised as the acyclic methyl-(−)-(*trans*)-(*trans*)-10,11-dihydroxyfarnesoate and its monocyclic derivative methyl-(+)-10-hydroxy-6,11-cyclofarnes-7(14)-enoate. The alkaloids were of the unusual aza-polycyclic and naphthyridine groups and included one new member of both classes. Examination of stem bark samples from the same source and from Sierre Leone showed the presence of the sesquiterpenes and the oxoaporphine alkaloid liriodenine but neither of the rarer alkaloid types.

INTRODUCTION

Cleistopholis patens (Benth.) Engl. and Diels (Annonaceae) is a large rain forest tree found throughout the west African rain forest zone, from Sierre Leone to Gabon [2]. The very fibrous stem bark is fragrant and is said to be a remedy for infective hepatitis whilst the root bark is used as a vermifuge [3]. A previous examination of the stem bark [4] revealed only two alkaloids, the oxoaporphines liriodenine and isomoschatoline, the former being very common in the Annonaceae. In this paper we report the results of a study of the root and stem bark of this species collected in Ghana and the stem bark of further material from Sierre Leone. Our investigations show the fragrance of the bark to be due to two novel sesquiterpenes while the root bark, but apparently not the stem bark, contains aza-polycyclic and naphthyridine alkaloids.

RESULTS AND DISCUSSION

Petrol (bp 40–60°) extraction of a root bark sample from Ghana gave two alkaloids and two sesquiterpenes. After acid–base partition the alkaloids were separated from the basic fraction by circular prep. TLC and the two sesquiterpenes from the neutral fraction by CC. The two sesquiterpenes were obtained in yields of 0.096% and 0.013%, were optically active, and analysed for $C_{16}H_{28}O_4$ and $C_{16}H_{26}O_3$, respectively. Acetylation of the major compound gave two products, a mono- and a diacetate; the minor compound gave only a monoacetate.

Spectral analysis revealed several features common to both compounds. UV and IR spectra suggested the presence of an α,β-unsaturated ketone. The ^{1}H NMR spectra (Table 1) showed resonances for a Me ester and for a relatively shielded olefinic proton coupled to a deshielded Me. The presence of a carbonyl resonance in the ^{13}C NMR spectra (Table 2) with signals for a strongly shielded tertiary olefinic carbon and a deshielded quaternary carbon together with a strong ion *m/z* 114 in the EI mass spectrum confirmed the presence of a $-CH_2C(Me)=CH-CO-OMe$ moiety in both compounds.

For the major sesquiterpene the NMR spectra revealed the presence of another olefinic centre, thereby requiring it to be acyclic, and signals indicative of secondary and tertiary alcohols. Changes in the resonance positions for two Me singlets, the secondary and tertiary alcohol centres and one methylene group on formation of the mono- and diacetates indicated the partial structure $CH_2CH(OH)C(OH)(Me)_2$. These data suggested that the sesquiterpene be assigned structure **1**. The *trans* configuration of the two double-bonds follows from the allylic coupling seen between the olefinic proton and methyl in each case. A further important EI mass spectral fragment at *m/z* 99 $[C_6H_{11}O]^+$ can be rationalized by fission of **1** α to the second olefin (i.e. C-7/C-8) with loss of H_2O. This appears to be the first report of **1** from a natural source. The corresponding acid is known as a product of the metabolism of 10,11-epoxy-(+)-farnesol by the fungi *Helminthosporium sativum* [5] and *Colletotrichum nicotianae* [6]. Available spectral data on the Me ester of the acid [5, 7] were in agreement with those recorded here for **1** and the close correspondence of OR values allows **1** to be assigned an *S*-configuration.

In addition to the α,β-unsaturated unit shared with **1** the NMR spectra of the minor sesquiterpene revealed only one other centre of unsaturation, in the form of an exocyclic methylene, thus requiring this compound to be monocyclic. Other features of the NMR spectra were the presence of a secondary alcohol, *gem*-substituted Me groups and a tertiary methine carbon. The EI mass spectrum gave major ions at *m/z* 153 $[C_{10}H_{17}O]^+$ and 139 $[C_9H_{15}O]^+$ with accompanying ions for loss of H_2O. The latter must represent the cyclic system plus attached

*Part 14 in the Series "Chemistry of the Annonaceae". For Part 13 see ref. [1].

Table 1. ^{1}H NMR chemical shift values and coupling constants (in brackets)

Position	1	1-Ac	1-(Ac)$_2$	2	2-Ac
H-2	5.65 *q* (1)	5.69 *q* (1)	5.66 *q* (1)	5.66 *q* (1)	5.66 *q* (1)
H-4/H-5	2.00–2.26 *m*	2.16 *s*	2.11–2.16 *m*	2.00–2.30 *m*	2.00–2.30 *m*
H-6	5.13 *tq* (1, 1)	5.10 *br s*	5.08 *tq* (1, 1)	2.20 *dd* (5, 1)	2.20 *dd* (5, 1)
H-8	2.00–2.26 *m*	2.16 *s*	2.11–2.16 *m*	2.00–2.30 *m*	2.00–2.30 *m*
H-9	1.40/1.55 *m*		1.63/1.93 *m*	1.90–1.50 *m*	2.05–1.50 *m*
H-10	3.31 *dd*	4.80 *dd*	5.11 *dd*	3.42 *dd*	4.67 *dd*
	(9.3, 1.1)	(10.2, 6.6)	(10.3, 2.6)	(9.3, 4.2)	(8.1, 4.4)
H-12	1.14 *s*	1.20 *s*	1.42 *s*	1.02 *s*	0.96 *s*
H-13	1.19 *s*	1.20 *s*	1.47 *s*	0.74 *s*	0.82 *s*
H-14	1.60 *d* (1)	1.59 *d* (1)	1.58 *d* (1)	4.58/4.89 *br s*	4.62/4.92 *br s*
H-15	2.14 *d* (1)	2.19 *d* (1)	2.14 *d* (1)	2.16 *d* (1)	2.16 *d* (1)
OMe	3.67 *s*	3.68 *s*	3.67 *s*	3.69 *s*	3.69 *s*
OAc		2.10 *s*	2.08/1.95		2.06 *s*

All spectra run in $CDCl_3$. **1** and **1**-(Ac)$_2$ at 360 MHz, **2** and **2**-Ac at 250 MHz, and **1**-Ac at 90 MHz.

Table 2. ^{13}C NMR chemical shift values (ppm) for sesquiterpenes

Carbon number	1	1-Ac	1-(Ac)$_2$	2-Ac
1	167.1	167.1	167.0	167.1
2	115.3	115.3	115.9	115.2
3	159.4	159.6	159.5	160.2
4	40.6	40.6	40.7	39.8
5	25.8	25.8	.26.0	28.3
6	123.4	123.6	128.7	51.8
7	135.9	135.1	135.0	146.5
8	36.5	36.0	35.9	30.7
9	29.8	27.9	27.8	23.8
10	77:9	79.5	77.0	78.2
11	72.8	72.3	82.6	39.1
12	22.3*	24.8*	20.8*	18.4_{ax}
13	26.3*	26.5*	22.1*	26.3_{eq}
14	15.8	15.9	15.9	109.6
15	18.6	18.7	18.7	18.8
OMe	50.5	50.6	50.5	50.6
OAc		170.9	170.1	170.3
		20.9	169.7	21.1
			22.1	
			22.1	

All spectra run at 90.56 MHz.
*Signals within a column interchangeable.

OH, Me and exocyclic methylene functions and is derived by fission α to the ring by a McLafferty rearrangement of the type noted by Cimino *et al.* [8].

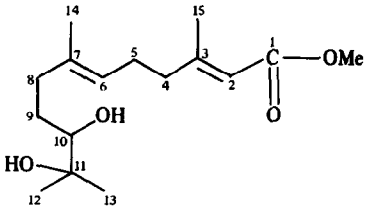
In view of the already established presence of **1** this minor sesquiterpene could be assigned structure **2**. The placement of the OH substituent at C-10 was confirmed by the pronounced shift in the ^{1}H resonances for the *gem* Me groups in the acetate and its assignment to the equatorial (β) configuration follows from the large axial-axial coupling noted for H-10 (Table 1). The ^{13}C NMR spectrum of **2**-Ac (Table 2) showed Me resonances at 18.4, 18.8 and 26.3 ppm. Following from **1** the 18.8 resonance was assigned to C-15 therefore requiring the 18.4 signal to be attributed to the axial C-12 and the 26.3 signal to the equatorial C-13. The relatively shielded position of the C-12 signal denotes the absence of any gauche effects on C-12 [9], thereby requiring that both adjacent substituents be equatorial, and therefore leading to the relative stereochemistry depicted in **2**.

NMR spectra of **2** revealed the persistent occurrence of a minor product. This could not be isolated but from the ^{13}C NMR spectrum of **2**-Ac resonances were noted that could be assigned to C-7, C-8 and C-14 of the 7(8)-en isomer **3** [10].

Sesquiterpenes of type **1** and **2** are very rare in higher plants. Monocyclic sesquiterpenes similar to **2** occur quite widely in marine natural products [11], the closest analogue being a C_{18}-terpenoid with an identical cyclogeranyl system [12]. Compound **1** bears a close relationship to C_{16}-juvenile hormone [6] although **1** occurs on the less active *S*-form of that hormone. Yingzhaosu-A (**4**) and B (**5**), reported [13] from the roots of another species of Annonaceae, *Artabotrys uncinatus*, show some similarities with **1** and **2**.

The more abundant of the two alkaloids from the petrol extract (yield 0.13%) analysed for $C_{13}H_9NO$. A full spectral analysis indicated that it was the known alkaloid onychine (**6**) which had previously been isolated from the trunk wood of *Onychopetalum amazonicum*, an annonaceous species from Brasil [14]. The co-identity of **6** with onychine was confirmed by its reduction to the corresponding dihydro derivative using $NaBH_4$. Chemical shifts for the previously unrecorded ^{13}C NMR spectrum were assigned by comparison with published data for related aza- and anthracene polycyclic compounds [15–18].

The minor alkaloid from the petrol extract was obtained in a yield of only 0.006% and analysed for $C_{14}H_9NO_2$. The difference of CO between this alkaloid and onychine could easily be rationalised as a second carbonyl function (ν_{max} 1695, 1685 cm^{-1}). The ^{1}H NMR spectrum confirmed the presence of the 4-methylpyridine system and of an *ortho*-disubstituted aromatic ring as in **6**, thus requiring the compound to be either an α-diketone (**7**) (two possible structures) or the γ-diketone (**8**). The



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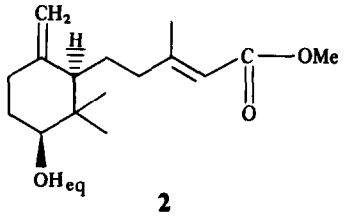

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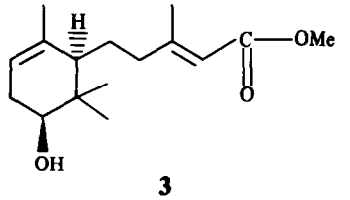

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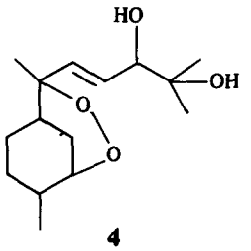

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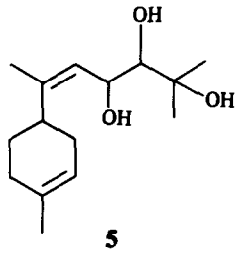

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relative symmetry of the chemical shift pattern of the aromatic protons with signals (1H each) at δ8.35 and 8.25 (both double doublets) for protons *peri* to carbonyl groups and a multiplet (2H) at δ7.81 could only be satisfied by the anthraquinoid-type structure (**8**). The ^{13}C NMR spectrum of **8** permitted assignment of only some resonances because of the limited amount of material available. Signals for tertiary carbons at 153.3 and 131.0 ppm agreed well with signals for C-2 and C-3 of **6**. The remaining four tertiary carbons were observed as pairs at 134.4 and 134.1 ppm and at 127.3 and 127.1 ppm, which agree closely with published data for the comparable anthraquinone skeleton [16]. This novel alkaloid has been assigned the trivial name cleistopholine. Its isolation is of particular interest from a biosynthetic viewpoint. Leboeuf *et al.* [13] suggested that **6** was formed from phenylalanine and an isopentenyl (isoprene) unit. Such a biosynthetic route is not directly applicable to cleistopholine.

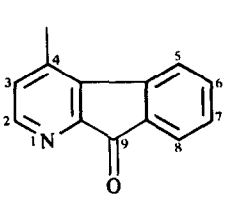
The chloroform extract of the root bark yielded, after acid–base extraction, more **1** and three basic compounds. Separation of the basic material by circular prep. TLC gave two alkaloids in workable amounts and a third in trace quantities only. The least polar compound (yield 0.1%) analysed for $C_{14}H_8N_2$ and gave spectral data in close agreement with those for eupolauridine (**9**), reported previously from *Eupomatia laurina* of the closely allied family Eupomatiaceae [19] and from *Cananga odorata* (Annonaceae) [20]. The previously unrecorded ^{13}C NMR spectrum of **9** is listed in Table 3.

The more polar major compound (yield 0.18%) analysed for $C_{14}H_8N_2O$ and its UV and IR spectra agreed closely with those of **9**. The EI mass spectrum was dominated by the loss of 16 mu followed by fragmentation identical to that of **9** indicating that this was the N-oxide of eupolauridine (**10**). The ^{1}H NMR and ^{13}C NMR spectra (Table 3) of **10** illustrate clearly the anticipated effects of N-oxidation on chemical shift values for both nuclei. This appears to be the first report of eupolauridine N-oxide. The relationship between **9** and **10** was confirmed by Zn–HCl reduction of **10** to give **9** and by N-oxidation of **9** with hydrogen peroxide–glacial acetic acid to give **10**. During the latter process a further product was obtained that analysed for $C_{14}H_8N_2O_2$. This was obviously the di-N-oxide (**11**), the ^{1}H NMR spectrum of which showed a return to the symmetry previously seen in **9**. The TLC characteristics of **11** were found to be identical to those of the third minor alkaloid so indicating that the di-N-oxide was also present in this species.

Extraction of the stem bark from the same collection yielded further **1** (0.046%) and **2** (0.016%) from the petrol extract whilst the chloroform extract gave the common oxoaporphine liriodenine which has previously been reported from this species [4]. Neither aza-polycyclic nor naphthyridine alkaloids could be detected in the stem bark extracts. Similar extraction of a second stem bark sample from Sierre Leone showed the same chemical profile as the original Ghanaian stem bark sample, yields being **1** (0.02%), **2** (0.01%) and liriodenine (0.025%). Once again the other alkaloid types appeared to be absent suggesting that in *C. patens* these alkaloids may be restricted to root bark only.

EXPERIMENTAL

Mps uncorr. UV: MeOH. IR: KCl discs: NMR spectra run in $CDCl_3$ with TMS as int. standard unless otherwise stated. EIMS: 70 eV, direct probe insertion at 150°. Petrol is bp 40–60° fraction.



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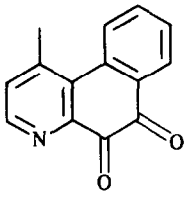

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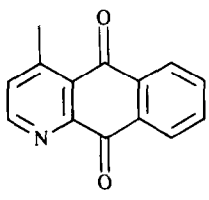

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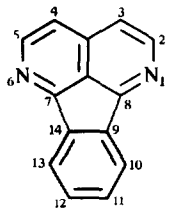

9

10 $N_1^+—O^-$

11 $N_1^+—O^-$ $N_6^+—O^-$

Table 3. ^{13}C NMR chemical shift values (ppm) for eupolauridine and eupolauridine N-oxide

Position	9	10
C-2	149.8	145.0
C-3	117.3	125.6
C-3a	135.0	127.6
C-4	117.3	116.5
C-5	149.8	148.5
C-7	162.7	158.2
C-7a	120.7	123.3
C-8	162.7	142.3
C-9	139.8	133.1
C-10	131.0	131.1*
C-11	122.5	121.6†
C-12	122.5	122.6†
C-13	131.0	130.8*
C-14	139.8	137.2

Spectra run in $CDCl_3$ at 90.56 MHz.

*,†Signals with same superscript interchangeable.

Plant material. Root and stem bark of *C. patens* was collected near Dompin, Ghana. A voucher, A. Enti FE-1297, has been deposited at the Herbarium of the Botanic Garden, Edinburgh. A further stem bark sample was collected on Tiwai Island, Sierre Leone (voucher P. G. Waterman 1001 at the Herbarium of the Royal Botanic Gardens, Kew).

Extraction of root bark. The powdered bark (500 g) was extracted with petrol, then $CHCl_3$ and finally MeOH. The petrol extract was concd and partitioned through acid–base (pH 10). The neutral fraction was subjected to CC over silica gel. Elution with petrol containing 6% EtOAc gave **2** (65 mg) followed by sitosterol (80 mg). Elution with 10% EtOAc gave **1** (480 mg). The basic fractions were separated by prep. TLC (silica gel; toluene–EtOAc–HOAc, 94:6:1) to give **6** (650 mg) followed by **8** (30 mg). The concd $CHCl_3$ extract was similarly treated and prep TLC of the basic fraction ($CHCl_3$–MeOH, 99·1) gave **9** (500 mg), **10** (900 mg), and **11** (trace only).

Methyl-(−)-(trans)-(trans)-10,11-dihydroxyfarnesoate (**1**). Colourless oil, $[\alpha]_D^{25}$ −9.6° (*c* 0.1, $CHCl_3$) (lit. [5] −12.1°). Found: $[M]^+$ 284.1994, $C_{16}H_{28}O_4$ requires 284.1987. UV λ_{max} nm (log ε): 230 (4.30). IR ν_{max} (film) cm^{-1}: 3400, 1720, 1650, 1440, 1230, 1150, 1080. ^1H NMR: see Table 1. ^{13}C NMR: see Table 2. EIMS *m/z* (rel. int): 284 $[M]^+$ (4), 266 $[M-H_2O]^+$ (25), 235 $[M-H_2O-OMe]^+$ (31), 226 (81), 207 (4), 193 (91), 153 (45), 151 (49), 114 (100), 111 (42), 99 (25), 59 (27). **1** (100 mg) dissolved in pyridine (10 ml) was treated with Ac_2O at 55° for 24 hr. Normal workup gave a mixture which was separated by prep. TLC (silica gel; toluene–EtOAc, 49:1) to give **1-Ac** (35 mg) and **1-Ac$_2$** (50 mg). **1-Ac** was obtained as a colourless oil. IR ν_{max} (film) cm^{-1}: 1720, 1710. ^1H NMR: see Table 1: ^{13}C NMR: see Table 2. **1-Ac$_2$** was obtained as a colourless oil. IR ν_{max} (film) cm^{-1}· 1720, 1710 (broad). ^1H NMR: see Table 1. ^{13}C NMR: see Table 2.

Methyl-(+)-(trans)-10-hydroxy-6,11-cyclofarnes-7(14)-oate (**2**). Colourless oil, $[\alpha]_D^{25}$ +15° (*c* 0.1, $CHCl_3$). Found: $[M]^+$ 266.1878; $C_{16}H_{26}O_3$ requires 266.1882 UV λ_{max} nm (log ε): 240 (4.18). IR ν_{max} (film) cm^{-1}: 3450, 1720, 1640, 1580, 1560, 1225, 1150. ^1H NMR: see Table 1 EIMS *m/z* (rel. int.): 266 $[M]^+$ (8), 248 (20), 235 (9), 192 (11), 153 (18), 152 (37), 140 (3), 135 (66), 122 (33), 121 (13), 114 (40), 107 (18), 59 (17). **2** (25 mg) was acetylated in the normal manner at room temp to give **2-Ac** (20 mg) as a colourless oil. IR ν_{max} (film) cm^{-1}: 1730, 1725. ^1H NMR: see Table 1. ^{13}C NMR: see Table 2.

Onychine (**6**). Pale yellow needles from petrol–EtOAc, mp 136–138° (lit. [14] 133–135°). Found: $[M]^+$ 195 0662, $C_{13}H_9NO$ requires 195 0684. UV, IR, EIMS in agreement with published data [14]. ^1H NMR (360 MHz): δ 2.59 (3H, *d*, *J* = 0.6 Hz, 4-Me), 6.91 (1H, *dd*, *J* = 5, 0.6 Hz, H-3), 7.38 (1H, *ddd*, *J* = 7.3, 7, 1.5 Hz, H-6), 7.54 (1H, *ddd*, *J* = 7.3, 7, 1.5 Hz, H-7), 7.64 (1H, *dd*, *J* = 7, 1.5 Hz, H-5), 7.78 (1H, *dd*, *J* = 7, 1 5 Hz, H-8), 8.37 (1H, *d*, *J* = 5 Hz, H-2). ^{13}C NMR (90.56 MHz): 17 1 (4-Me), 120 7 (C-5), 123.5 (C-7), 125.3 (C-8), 130.6 (C-3), 134 8 (C-6), 134.8 (C-8a), 143 0 (C-4b), 147.3 (C-4a), 152.6 (C-2), 165.1 (C-9a), 192.9 (C-9).

Dihydroonychine. **6** (80 mg) in EtOH (15 ml) was treated with

$NaBH_4$ at room temp for 24 hr. The reaction mixture was concd and extracted with HCl. The HCl soln was basified and extracted into Et_2O from which dihydroonychine recrystallised as needles, mp 155–157° (lit. [14] 156–158°), UV, IR, ^1H NMR in agreement with lit. [14].

Cleistopholine (**8**). Pale yellow amorphous solid, mp 185–190°. Found. $[M]^+$ 223.0626; $C_{14}H_9NO_2$ requires 223.0633. UV λ_{max} nm (log ε): 250 (4.65), 263 sh (4.05), 322 (3.80). IR ν_{max} cm^{-1}: 1695, 1685, 1600, 1300, 980, 710. ^1H NMR (360 MHz). δ2.90 (1H, *d*, *J* = 0.6 Hz, 4-Me), 7.48 (1H, *dd*, *J* = 4.8, 0.6 Hz, H-3), 7.81 (2H, *m*, H-6, H-7), 8.25 (1H, *dd*, *J* = 7, 2.2 Hz, H-5 or H-8), 8.35 (1H, *dd*, *J* = 7, 2.2 Hz, H-5 or H-8), 8.88 (1H, *d*, *J* = 4.8 Hz, H-2). ^{13}C NMR (90.56 MHz): 22.7 (Me-4), 127.1, 127.3 (C-5 and C-8), 131.0 (C-3), 134.1, 134.4 (C-6 and C-7), 153.3 (C-2). EIMS *m/z* (rel. int.): 223 $[M]^+$ (100), 195 $[M-CO]^+$ (77), 180 (10), 167 (19), 166 (14), 140 (6), 77 (7).

Eupolauridine (**9**). Yellow needles from $CHCl_3$, mp 150–152° (lit. [20] 156°). Found: $[M]^+$ 204.0695; $C_{14}H_8N_2$ requires 204.0687. UV, IR in agreement with lit. [19, 20]. ^1H NMR (90 MHz): δ7.40 (2H, *d*, *J* = 7 Hz, H-3, H-4), 7.45 (2H, *ddd*, *J* = 7, 7, 2 Hz, H-11, H-12), 7.98 (2H, *dd*, *J* = 7, 2 Hz, H-10, H-13), 8.70 (2H, *d*, *J* = 7 Hz, H-2, H-5). ^{13}C NMR: see Table 3. EIMS *m/z* (rel. int.): 204 $[M]^+$ (100), 177 (8). 151 (2), 102 (11).

Eupolauridine N-oxide (**10**). Yellow needles from $CHCl_3$, mp 186–188° Found: $[M]^+$ 220.0639; $C_{14}H_8N_2O$ requires 220.0637. UV λ_{max} nm (log ε): 245 (4.28), 275 sh (4.05), 284 (4.15), 301 sh (4.06), 333 (3.60), 349 (3.65), 395 (3.70). ^1H NMR (90 MHz): δ7.40 (1H, *ddd*, *J* = 7, 7, 2 Hz, H-12), 7.46 (1H, *d*, *J* = 7 Hz, H-4), 7.50 (1H, *ddd*, *J* = 7, 7, 2 Hz, H-11), 7.51 (1H, *d*, *J* = 7 Hz, H-3), 8.06 (1H, *dd*, *J* = 7, 2 Hz, H-13), 8.13 (1H, *d*, *J* = 7 Hz, H-2), 8.43 (1H, *dd*, *J* = 7, 2 Hz, H-10), 8.66 (1H, *d*, *J* = 7 Hz, H-5). ^{13}C NMR: see Table 3. EIMS *m/z* (rel. int.): 220 $[M]^+$ (65), 204 (100), 177 (6), 165 (26), 151 (2), 102 (12). **10** (50 mg) was reacted with Zn/HCl at room temp. The reaction mixture was chilled, diluted with H_2O, basified with NH_3 and extracted into $CHCl_3$ to give **9** (35 mg).

Eupolauridine di-N-oxide (**11**). **10** (50 mg) in HOAc (25 ml) was refluxed with 30% vol. H_2O_2 (2 ml) at 70° for 24 hr. The reaction mixture was filtered through palladized carbon and the filtrate concd and basified with NH_3. Extraction with $CHCl_3$ yielded **11** (25 mg) identical on TLC to the minor product extracted from the root bark $CHCl_3$ extract. It recrystallised from $CHCl_3$ as orange plates, mp 190–195°. Found: $[M]^+$ 236.0589; $C_{14}H_8N_2O_2$ requires 236.0586. UV λ_{max} nm (log ε): 230 (3.96), 250 (4.24), 295 (4.30), 405 (3 62), 440 (3.64) ^1H NMR (90 MHz): δ7.45 (2H, *d*, *J* = 7 Hz, H-3, H-4), 7.55 (2H, *ddd*, *J* = 7, 7, 2 Hz, H-11, H-12), 8.08 (2H, *d*, *J* = 7 Hz, H-2, H-5), 8.48 (2H, *dd*, *J* = 7, 2 Hz, H-10, H-13). EIMS *m/z* (rel. int.): 236 $[M]^+$ (41), 220 (100), 204 (33), 165 (14), 164 (13), 102 (2).

Extraction of stem bark sample from Ghana. The ground bark (400 g) was extracted as above. CC of the petrol extract yielded **1** and **2**. Extraction of the $CHCl_3$ conc through acid–base yielded, in the $CHCl_3$ extract from the base layer, *liriodenine* (160 mg), mp 276–278°, with spectral characteristics in close agreement with those reported elsewhere [4].

Extraction of stem bark sample from Sierre Leone. This gave identical results to the stem bark sample from Ghana.

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REFERENCES

1. Hasan, C. M., Healey, T. G. and Waterman, P. G. (1985) *Phytochemistry* **24**, 192.
2. Hutchinson, J. and Dalziel, J. M. (1954) *Flora of West Tropical Africa*, 2nd. Edn, Vol. 1, pp. 38–39. Crown Agents, London.
3. Irvine, R. F. (1961) *Woody Plants of Ghana*, p. 6. Oxford University Press, Oxford.
4. Atta, S. E. A., Ammar, H. A., Phoebe, C. H., Schiff, P. L. and Slaktin, D. J. (1982) *J. Nat. Prod.* **45**, 476.
5. Suzuki, Y. and Marumo, S. (1972) *Tetrahedron Letters* 1887.
6. Imai, K., Marumo, S. and Ohtaki, T. (1976) *Tetrahedron Letters* 1211.
7. Kuhnz, W. and Rembold, H. (1981) *Org. Magn. Reson.* **16**, 138.
8. Cimino, G., De Stefano, S., Guerriero, A. and Minale, L. (1975) *Tetrahedron Letters* 1417.
9. Crews, P. and Kho-Wiseman, E. (1978) *Tetrahedron Letters* 2483.
10. Capon, R. J., Ghisalberti, E. L. and Jefferies, P. R. (1981) *Aust. J. Chem.* **34**, 1775.
11. Faulkner, D. J. (1984) *Nat. Prod. Reps.* **1**, 251.
12. Ravi, B. N., Murphey, P. T., Lidgard, R. O., Warren, R. G. and Wells, R. J. (1982) *Aust. J. Chem.* **35**, 171.
13. Leboeuf, M., Cavé, A., Bhaumik, P. K., Mukherjee, B. and Mukherjee, R. (1982) *Phytochemistry* **21**, 2783.
14. Almeida, M. E. L., Braz, R., von Bulow, M. V., Gottlieb, O. R. and Maia, G. J. S. (1976) *Phytochemistry* **15**, 1186.
15. Castelao, J. F., Gottlieb, O. R., De Lima, R. A., Mesquita, A. A. L., Gottlieb, H. E. and Wenkert, E. (1977) *Phytochemistry* **16**, 735.
16. Berger, Y. and Castonguay, A. (1978) *Org. Magn. Reson.* **11**, 375.
17. Fomichov, A. A., Svoren, V. A., Golovtsov, N. I., Soldatenkov, A. T. and Prostakov, N. S. (1982) *Org. Magn. Reson.* **19**, 24.
18. Haber, A. and Hilton, B. D. (1983) *Org. Magn. Reson.* **21**, 168.
19. Bowden, B. F., Picker, K., Ritchie, E. and Taylor, W. C. (1975) *Aust. J. Chem.* **28**, 2681.
20. Leboeuf, M. and Cavé, A. (1977) *Lloydia* **39**, 459.