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NON-ALKALOIDAL CONSTITUENTS OF *VIROLA ELONGATA* BARK

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Key Word Index—*Virola elongata*; Myristicaceae; bark; stilbenes; neolignans; bis-tetrahydrofuran lignans; tetrahydrofuran lignans.

Abstract—Eleven of the major non-polar constituents of the dried bark of *Virola elongata* were isolated. A new neolignan, virolongin, two new lignans, dihydrosesartemin and β-dihydroyangambin, as well as the neolignan, eusiderin, the lignans, epi-sesartemin, sesartemin, epi-yangambin and yangambin, the *cis* and *trans* isomers of 3,5,4′-trimethoxystilbene and sitosterol were identified. The structures of virolongin, dihydrosesartemin and β-dihydroyangambin were determined.

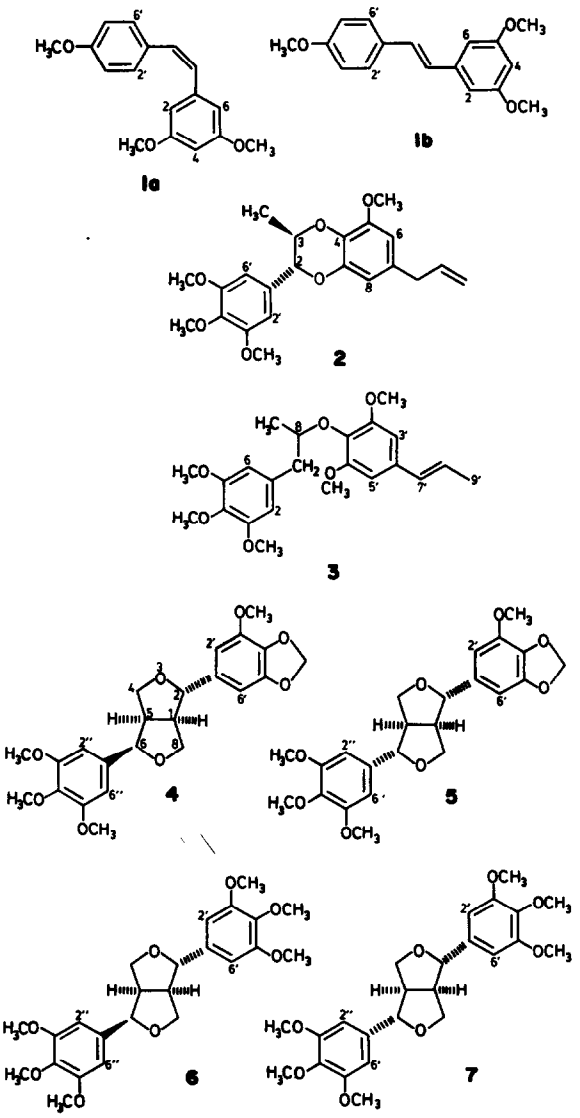
INTRODUCTION

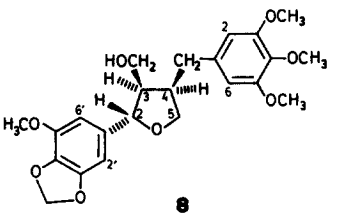
Interest in the chemistry of Amazonian Myristicaceae has been elicited by the medicinal applications of certain species of this floristically important group [1, 2]. Tryptamine derivatives, neolignans and lignans have been isolated as the biologically active constituents [1]. *Virola elongata* and *V. theiodora* are well known in the ethnobotanical literature for their uses by the Yanomamö Indians as a hallucinogenic snuff and also as an arrow poison [3, 4]. The tryptamines *N*,*N*-dimethyltryptamine and 5-methoxy-*N*,*N*-dimethyltryptamine have been identified as the primary hallucinogenic constituents of the resin [5–7]. The non-alkaloidal constituents of the resin appear never to have been examined. We report here on the identity of the major non-polar constituents of the bark resin of *V. elongata*.

RESULTS AND DISCUSSION

Eleven of the major constituents of a diethyl ether extract of *Virola elongata* bark were isolated as described in the Experimental and identified by spectroscopic means. Sitosterol was the only phytosterol identified. The stilbenes, 3,5,4′-trimethoxy-*trans*-stilbene (**1b**) and its *cis* isomer (**1a**) were found in *ca* equal proportions. Only the former has been described as a naturally occurring constituent. Eusiderin (**2**) and a hitherto undescribed compound, virolongin (**3**), comprised the neolignans. Four bis-tetrahydrofuran lignans were identified: epi-sesartemin (**4**), sesartemin (**5**), epi-yangambin (**6**) and yangambin (**7**). Finally, two new tetrahydrofuran compounds, dihydrosesartemin (**8**) and β-dihydroyangambin (**9**), were identified.

Compounds **1a** and **1b** behaved similarly on TLC in several solvent systems. Both formed a pink colour upon spraying with sulphuric acid. The UV spectrum of **1b** displayed bands of *ca* equal intensity at 319 and 305 nm, corresponding to bands I and II, respectively, which are characteristic of stilbenes [8]. All of the spectral data obtained for **1b** are in close agreement with those presented for 3,5,4′-trimethoxy-*trans*-stilbene [9] and its structure was thus assigned. The UV spectrum of **1a**, with





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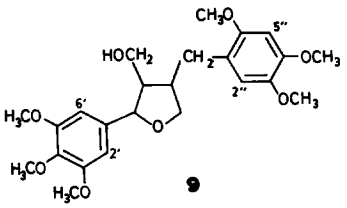

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a single band at 283 nm, is suggestive of a *cis*-stilbene derivative [8]. The mass spectrum is very similar to that of **1b**, both displaying a $[M]^+$ of *m/z* 270. In the 400 MHz ^{1}H NMR spectrum of **1a**, the aromatic AB pattern of C-3′,5′; C-2′,6′, the signals of the two vinyl protons and the C-2, C-4 and C-6 proton signals are all present but shifted upfield somewhat from those of **1b**. The coupling constant of the vinyl protons of **1a** and **1b** are 12 and 16 Hz, respectively. These values are characteristic of unsymmetrical *cis* and *trans* isomers. On the basis of these data, **1a** is assigned as the *cis* isomer of **1b**. The occurrence of this compound is noteworthy since stilbenes are normally present naturally in the more stable *trans* form [10].

Compounds **2** and **3** demonstrated similar behaviour by TLC. Both displayed a pink colour upon spraying with sulphuric acid. Compound **2** was found to have an MW of 386 by mass spectrometry. Proton and methoxyl counts by NMR and the mass spectrum revealed the formula $C_{18}H_{13}O_2(OMe)_4$. The fragment *m/z* 208 suggested the presence of the system $(MeO)_3C_6H_2CHCHMe$. Further analysis showed the spectral data to be identical to those reported for the benzodioxan neolignan, eusiderin [11–13]. The precise structure of that compound has been established definitively by LIS data [14]. The chemical shift of Me-3 (δ1.26) and the value for *J* (8 Hz) by ^{1}H NMR spectroscopy are evidence for the *trans* relationship of the Ar-2/Me-3 groups [13] and support the identification of **2** as eusiderin. Eusiderin has previously been reported from *V. guggenheimii* and *V. pavonis* [14] and various genera of the family Lauraceae [12].

Compound **3** bears considerable resemblance to eusiderin (**2**), based upon its UV, ^{1}H NMR and mass spectra. The presence of the fragments *m/z* 209 and 208 suggest the presence of the groups $(MeO)_3C_6H_2CH_2CHMe$ and $(MeO)_3C_6H_2CHCHMe$, respectively. This, combined with the appearance of two sets, each of two equivalent aromatic protons and five methoxy groups in the ^{1}H NMR spectrum, is indicative of the presence of an 8-*O*-4′-neolignan. The ^{1}H NMR spectrum closely resembles that reported for 1-(3,4,5-trimethoxyphenyl)-2-allyl-2,6-dimethoxyphenoxy-propane, a compound isolated from seeds of *Myristica fragrans* [15], also of the Myristicaceae. The only differences are the occurrence of the signals attributed to the aromatic allylic substituent as a doublet (3H, *J* = 6 Hz) at δ1.87 and multiplets between δ6.05 (1H) and 6.25 and δ6.2 and 6.5 (1H) in the spectrum of **3**. These three signals would, instead, be expected to result from an

Table 1. ^{1}H NMR spectral data of bis-tetrahydrofuran lignans isolated from *Virola elongata* bark

Proton	Epi-sesartemin (4)	Sesartemin (5)	Epi-yangambin (6)	Yangambin (7)
1H	2.91 (1H), *m*	3.05 (1H), *m*	2.95 (1H), *m*	3.08 (1H), *m*
2H	4.85 (1H), *d*	4.70 (1H), *d*	4.84 (1H), *d*	4.75 (1H), *d*
	J = 5.5	*J* = 4.0	*J* = 5.0	*J* = 5.5
4α H	3.70–3.95	4.15–4.50	3.70–4.00	4.20–4.43
	(1H), *m*	(1H), *m*	(1H), *m*	(1H), *m*
4β H	3.15–3.5	3.70–4.10	3.20–3.55	3.82–3.97
	(1H), *m*	(1H), *m*	(1H), *m*	(1H), *m*
5H	3.15–3.50, *m*	3.05 (1H), *m*	3.20–3.55	3.08 (1H), *m*
6H	4.41 (1H), *d*	4.70 (1H), *d*	4.43 (1H), *d*	4.75 (1H), *d*
	J = 7.0	*J* = 4.0	*J* = 7.0	*J* = 5.5
8α H	4.00–4.25	4.15–4.50	4.00–4.25	4.20–4.43
	(1H), *m*	(1H), *m*	(1H), *m*	(1H), *m*
8β H	3.70–3.95	3.70–4.10	3.70–4.00	3.82–3.97
	(1H), *m*	(1H), *m*	(1H), *m*	(1H), *m*
2′, 2″	6.56 (2H), *s*	6.55 (4H), *s*	6.57 (4H), *s*	6.58 (4H), *s*
6′, 6″	6.53 (2H), *s*			
OMe	3.90 (3H), *s*	3.91 (3H), *s*	3.88 (12H), *s*	3.86 (12H), *s*
	3.87 (3H), *s*	3.87 (3H), *s*	3.83 (6H), *s*	3.83 (6H), *s*
	3.85 (6H), *s*	3.82 (6H), *s*		
OCH_2O	5.95 (2H), *s*	5.95 (2H), *s*	—	—

Data are presented (in order) as: chemical shift (δ, relative to TMS); integral value (number of protons); multiplicity of peaks; coupling constant (in Hz). Spectra were recorded in $CDCl_3$ at 80 MHz.

Table 2. ^{13}C NMR spectral data of bis-tetrahydrofuran lignans isolated from *Virola elongata* bark

Carbon No.	Epi-sesartemin (4)	Sesartemin (5)	Epi-yangambin (6)	Yangambin (7)
1	54.52	54.41	54.36	54.29
2	87.59	85.85 (c)	87.66	85.88
4	71.03	71.87 (d)	71.00	71.91
5	49.96	54.41	49.90	54.29
6	82.11	86.02 (c)	82.06	85.88
8	69.99	72.00 (d)	69.77	71.91
1′	135.88	135.86	136.69	136.66
1″	133.97	136.77	133.89	136.66
2′	105.73 (a)	105.73 (e)	103.00	102.98
2″	102.73	102.94 (e)	102.69	102.98
3′	153.21	153.29 (f)	153.32	153.39
3″	153.21	153.48 (f)	153.13	153.39
4′	149.06 (b)	149.20 (g)	137.60	137.64
4″	137.09	136.77	137.00	137.64
5′	143.62 (b)	143.72 (g)	153.32	153.39
5″	153.21	153.48	153.13	153.39
6′	101.39 (a)	101.52 (e)	103.00	102.98
6″	102.73	102.94 (e)	102.69	102.98
OMe	56.13, 56.66, 60.77	56.24, 57.51 60.86	56.07, 60.68	56.16, 60.73
OCH_2O	100.11	100.09	—	—

Chemical shifts are given in δ (ppm) relative to TMS; δ(TMS) = δ($CDCl_3$) + 77.0 ppm; recorded at 20 MHz in $CDCl_3$. Values followed by letters (in parentheses) are interchangeable. Spectra were obtained in uncoupled mode; assignments were made by comparison with previously reported values.

aromatic propenyl group [13]. Double resonance experiments further supported these assignments. Irradiation at δ1.9 caused the signal at δ6.05–6.25 to collapse and irradiation at δ6.2 caused the doublet at δ1.87 to appear as a singlet.

Compounds **4** and **5** also behaved similarly in several chromatographic systems. Two spots, forming a brown colour upon spraying with sulphuric acid, were distinguished by TLC. Both compounds were found to have the formula $C_{23}H_{26}O_8$ by HR mass spectrometry and the ^1H NMR spectrum clearly indicated the presence of four methoxy groups, one methylenedioxy group and two pairs of equivalent aromatic protons. Furthermore, signals between δ3.0 and 4.5 indicated the presence of a bis-tetrahydrofuran ring. These compounds were, therefore, clearly 2,6-diaryl-3,7-dioxabicyclo-[3,3,0]-octane type lignans. The C-1,C-5 bond of naturally occurring bis-tetrahydrofuran lignans is characteristically in the *cis* configuration and the ^1H NMR and ^{13}C NMR spectra obtained (Tables 1 and 2) indicate that this is also true of **4** and **5**. The aryl substituents of C-2 and C-6 can be either axial or equatorial, allowing for three types of stereoisomers. Compound **4** was concluded to be an axial–equatorial isomer on the basis of the following features of its ^1H NMR spectrum [16, 17]: (1) a difference in C-1 and C-5 methine proton chemical shifts (δ2.91 and 3.15–3.5, respectively); (2) a difference in the chemical shifts of the benzylic protons at C-2 and C-6 (δ4.85 and 4.41, respectively); (3) the presence of one axial (C-4) methylene proton upfield (δ3.15–3.5) from the 'normal' position (δ3.8–4.0) due to shielding by the axial aromatic ring and an equatorial methylene proton (C-8) downfield between δ4.0 and 4.25, due to deshielding by the equatorial aromatic ring.

Chiba *et al.* [18] used ^{13}C NMR spectroscopy to establish the positions of aryl groups of unsymmetrically substituted bis-tetrahydrofuran lignans while Greger and Hofer [19] based their assignment of stereochemistry on the lanthanide-induced shift technique. In the present study, the relative configurations were assigned on the basis of ^{13}C NMR spectra. The chemical shifts of C-1′ and C-1″ are particularly useful in determining the stereochemistry of attachment of the phenyl group to the bis-tetrahydrofuran skeleton [17]. Compounds **6** and **7** are known, symmetrically substituted bis-tetrahydrofuran lignans and were identified on the basis of their melting points, optical rotations and UV, IR, mass and ^1H NMR spectral data, which agreed closely with published information [20–24]. The ^{13}C NMR data of **6** and **7** were compared with those of the unsymmetrically substituted **4** and **5** and the assignments were made on this basis. The 1′ and 1″ carbons of the diequatorially substituted compound, yangambin (**7**), have chemical shifts of 136.66 ppm, a value that compares well with those published by Pelter and Ward [17] for similar lignans. The axial 3,4,5-trimethoxyphenyl substituent of epi-yangambin (**6**), which has a chemical shift of 133.89 ppm (Table 2), is easily distinguished from the equatorial one. The similarity between this value (133.89 ppm) and the signal seen in the spectrum of **4** (133.97 ppm) is taken as

evidence that the 3,4,5-trimethoxyphenyl substituent is in the axial position in **4**. The remaining C-1 signal (135.88 ppm) was assigned to the 3-methoxy-4,5-methylenedioxyphenyl substituent. Since this compound was known, from the ^{1}H NMR spectrum, to be an axial–equatorial isomer, this latter substituent was assigned the equatorial position by default. The ^{13}C NMR spectrum of the diequatorial **5** supports these assignments since it has signals at 135.86 and 136.77 ppm, values which correspond closely to those assigned above for equatorial 3-methoxy-4,5-methylenedioxyphenyl and 3,4,5-trimethoxyphenyl substituents, respectively. All other ^{13}C NMR signals showed close agreement with the spectra reported for similar bis-tetrahydrofuran lignans [17].

The mass spectra of **4** and **5** are almost identical and bear close resemblance to those of **6** and **7**, which are also almost identical. The molecular formulae for all of the fragments described for **4** and **5** were obtained from measurements by high-resolution mass spectrometry. The basic fragmentation pathways described by Pelter [25] and Duffield [26] are easily identifiable in the mass spectra of **4**–**7**. As has been observed by others [25, 27], reliable differences in the structures of isomers are not identifiable.

Compounds **8** and **9** are the most polar constituents of the ether extract. They are separated easily by TLC, **8** giving a salmon-pink coloured spot with sulphuric acid and **9** a grey colouration. The mass spectra of these two compounds were especially informative since they produced $[M]^+$ ions with m/z 432 and 448, respectively. These values are just 2 mu greater than the parent ions of sesartemin and yangambin, respectively. Further similarities in the mass spectra of all four compounds were apparent.

The mass spectrum of dihydrosesartemin (**8**) showed two series of fragments: m/z 181, 169, 168 and 165, 153, 152, indicating the presence of both 3-methoxy-4,5-methylenedioxyphenyl and 3,4,5-trimethoxyphenyl substituents. The greater abundance of the peak at m/z 181 than that at m/z 165 was taken as evidence that the trimethoxy-substituted aromatic group was a benzyl, rather than a phenyl, substituent. The remaining features of the mass spectrum can be rationalized by assuming the compound to be a substituted tetrahydrofuran. The fragmentation pattern has been interpreted according to the schemes presented by Pelter *et al.* [28] and Pelter [25]. The ^{1}H NMR spectrum supported the proposal that the compound was a substituted tetrahydrofuran and provided information on its relative configuration. Hall *et al.* [29] have discussed the applicability of NMR in assigning the conformation of furanoses in solution. The variety of tetrahydrofuran lignans presently known is not great and detailed ^{1}H NMR spectra have been reported in only a limited number of cases. Few data are therefore available for comparison. From the existing data, it appears that the feature that can be most easily determined is the relative configuration at the benzyl carbon. A *cis* orientation of constituents about the C-2–C-3 bond will result in deshielding of the benzyl proton and a shift downfield in its resonance to *ca* δ5.5 [30–35]. A *trans* orientation results in the C-2 proton having a chemical shift of *ca* δ4.7. The corresponding signal observed in the spectrum of **8** is a doublet, δ4.78. This value agrees well with the assignment of the *trans* configuration. Although the published data are insufficient to allow the use of coupling constant as a definitive criterion for assigning configuration, the measured value, $J = 6.3$ Hz, is in line with several values previously reported for the *trans* configuration about the C-2–C-3 bond of a substituted tetrahydrofuran [30, 33].

The relative configuration of the tetrahydrofuran lignan (+)-lariciresinol has been established by chemical methods. Its optical rotation has been reported as $[\alpha]_D^{25}$ +17.5° [36]. The optical rotation of **8** was found to be $[\alpha]_D^{25}$ +11.8°. These two values were judged to be sufficiently similar to form the basis for assigning the relative configuration of the remaining carbon of **8**. The configuration is therefore 2*S*,3*R*,4*R*, identical to that of (+)-lariciresinol.

The mass spectrum of **9** is analogous to that of dihydrosesartemin (**8**) suggesting that it, too, is biosynthetically related to a bis-tetrahydrofuran lignan. It appears to differ only in the opening of the furan ring, leaving a free hydroxyl group. When the ^{1}H NMR spectrum is examined, however, it is apparent that a difference exists in the type of aromatic substituents present in **9** and yangambin or epi-yangambin. Instead of two singlets, each arising from two equivalent aromatic protons, one singlet integrating for two protons (δ6.66) and two single-proton singlets at δ6.63 and 6.36 are observed. This pattern is similar to the singlets at δ6.84 and 6.43 which were observed for the 3,4-methylenedioxy-6-methoxyphenyl group by Russel and Fenemore [16]. Although the positioning of the aromatic groups cannot be unambiguously defined on the basis of only the ^{1}H NMR spectrum, the structure has been tentatively assigned on the basis of a comparison of the chemical shifts with data from related compounds. In the ^{1}H NMR spectrum of **8**, the chemical shifts of the C-2′ and C-6′ protons of the methoxy-methylenedioxybenzyl substituent, which are resolved into two peaks at δ6.53 and 6.54, are downfield from the signal of the corresponding C-2″ and C-6″ protons of the phenyl substituent opposite (δ6.40). Assuming the same relationship to exist in the ^{1}H NMR spectrum of β-dihydroyangambin, the lower field signal (a two-proton singlet, δ6.66) is assigned to the protons of the benzyl substituent. This would correspond to the two equivalent protons of the 3,4,5-trimethoxybenzyl group. The remaining two aromatic singlets (integrating at one proton each), with chemical shifts δ6.63 and 6.36, are assigned to the C-5 and C-2 protons, respectively. These chemical shifts are in agreement with ^{1}H NMR data published for other lignans [36–38].

Although the optical rotation of **9**, $[\alpha]_D^{25}$ +15.1°, is similar to that of (+)-lariciresinol, $[\alpha]_D^{25}$ +17.5°, the ^{1}H NMR spectra of **8** and **9** do not agree completely. The greatest difference is in the coupling constant of the C-2 proton: $J = 8.5$ Hz for **9** and $J = 6.3$ Hz for **8**. We have therefore not attempted to assign the stereochemistry of this compound.

EXPERIMENTAL

Mps are uncorr. Optical rotations were carried out in 1 dm cells. ^{1}H NMR spectra were recorded in $CDCl_3$ on either an 80 or a 400 MHz instrument using TMS as internal standard. ^{13}C NMR were obtained at 20 MHz in $CDCl_3$ using TMS as ref. MS were recorded at 70 eV by direct insertion.

Plant material. Bark was collected near the village of Brillo Nuevo on the Rio Ampiyacu, a Peruvian tributary of the Amazon. Voucher specimens (D. McKenna No. 59) have been deposited at UNAP herbarium in Iquitos, San Marcos Herbarium in Lima, the Chicago Field Museum and the UBC

herbarium. The identification was carried out by Dr. W. A. Rodrigues, INPA, Manaus, Brazil. The dried bark (1.3 kg) was milled and extracted (4 ×) at room temp. with Et_2O.

Chromatography. After evapn *in vacuo*, the residue was subjected to chromatography using a Chromatotron (Harrison Research Associates) utilizing prep. (4 mm) plates coated with silica gel PF_{254} (Merck). Repeated chromatography, using petrol–Et_2O–MeCN (12:12:1, 6:6:1 and 3:3:1) yielded each of the following compounds. They are presented in order of elution. TLC analysis was carried out on precoated silica gel 60 F-254 plates (Merck) developed with petrol–Et_2O–MeCN (6:6:1).

Sitosterol. 425 mg, mp 133–135° (from Et_2O), ^1H NMR and MS data agree with data obtained for an authentic sample (Sigma). Chromatography on TLC (silica gel) using heptane–$CHCl_3$–EtOH (25:25:1) and petrol–Et_2O–MeCN (12:12:1) was also identical to that of an authentic sample.

3,5,4′-Trimethoxy-cis-stilbene (**1a**). 23 mg, mp 73–74° (from Et_2O). UV $\lambda_{max}^{cyclohexane}$ nm (log ε): 283 (4.50), 235 sh (4.64), 214 (4.97). ^1H NMR (400 MHz, $CDCl_3$): δ 3.65 (6H, *s*, 2 × OMe), 3.78 (3H, *s*, OMe), 6.32 (1H, *t*, *J* = 2 Hz, H-4), 6.43 (2H, *d*, *J* = 2 Hz, H-2, H-6), 6.43 (1H, *d*, *J* = 12 Hz, vinyl), 6.52 (1H, *d*, *J* = 12 Hz, vinyl), 6.77 (2H, *d*, *J* = 9 Hz, H-3′, H-5′), 7.21 (2H, *d*, *J* = 9 Hz, H-2′, H-6′). EIMS (probe) 70 eV, *m/z* (rel. int.): 270 $[M]^+$ (100), 239 (12), 224 (12), 212 (8), 196 (11), 195 (13), 181 (10), 169 (10), 165 (10), 153 (13), 152 (19), 149 (12), 141 (9), 135 (9), 127 (8), 115 (15), 104 (10), 95 (11), 91 (17), 85 (11), 83 (11), 81 (15), 71 (15), 69 (22).

3,5,4′-Trimethoxy-trans-stilbene (**1b**). 41 mg, mp 56–57° (from Et_2O). UV $\lambda_{max}^{cyclohexane}$ nm (log ε): 335 sh (4.45), 318 (4.68), 303 (4.72), 235 sh (4.42), 216 (4.66). ^1H NMR (400 MHz, $CDCl_3$): δ 3.81 (9H, *s*, 3 × OMe), 6.38 (1H, *d*, *J* = 2 Hz, H-4), 6.65 (2H, *d*, *J* = 2 Hz, H-2, H-6), 6.90 (2H, *d*, *J* = 9 Hz, H-3′, H-5′), 6.90 (1H, *d*, *J* = 16 Hz, vinyl), 7.04 (1H, *d*, *J* = 16 Hz, vinyl), 7.44 (2H, *d*, *J* = 9 Hz, H-2′, H-6′). EIMS (probe) 70 eV, *m/z* (rel. int.): 270 $[M]^+$ (100), 239 (14), 224 (11), 212 (8), 196 (9), 195 (10), 181 (7), 169 (7), 167 (13), 165 (8), 153 (9), 152 (13), 149 (37), 141 (7), 135 (7), 128 (8), 115 (12), 104 (7), 91 (12), 83 (9), 76 (11), 71 (25), 70 (23), 69 (27).

Eusiderin (**2**). 28 mg, mp 93–95° (from Et_2O). UV λ_{max}^{MeOH} (log ε) nm: 271 (3.21), 234 sh (4.24), 230 (4.78). $[\alpha]_D^{25}$ −10.4° in $CHCl_3$. ^1H NMR (80 MHz, $CDCl_3$): δ 1.26 (3H, *d*, *J* = 6 Hz, Me-3), 3.28 (2H, *d*, *J* = 7 Hz, CH_2), 3.85 (3H, *s*, OMe), 3.88 (9H, *s*, 3 × OMe), 3.9–4.3 (1H, *m*, H-3), 4.56 (1H, *d*, *J* = 8 Hz, H-2), 4.9–5.25 (2H, *m*, $=CH_2$), 5.7–6.25 (1H, *m*, CH=), 6.37 (1H, *d*, *J* = 2 Hz, H-6), 6.48 (1H, *d*, *J* = 2 Hz, H-8), 6.58 (2H, *s*, H-2′, H-6′). EIMS (probe) 70 eV, *m/z* (rel. int.): 386 $[M]^+$ (22), 372 (5), 344 (3), 343 (3), 312 (3), 311 (4), 302 (5), 210 (10), 209 (72), 208 (100), 205 (13), 195 (5), 194 (22), 193 (75), 192 (6), 191 (28), 181 (11), 179 (15), 178 (12), 177 (9), 168 (5), 165 (15), 164 (8), 163 (9), 161 (6), 151 (10), 150 (18), 149 (48), 148 (7), 147 (7), 137 (13), 135 (19), 133 (18), 132 (8), 123 (11), 121 (14), 119 (10), 107 (19), 105 (23), 104 (11), 103 (10), 97 (13), 95 (13), 91 (50), 85 (17), 83 (18), 81 (14), 79 (28).

Virolongin (**3**). 34 mg. Colourless oil. UV λ_{max}^{MeOH} nm (log ε): 268 (3.35), 227 (4.04). $[\alpha]_D^{25}$ −12.4° in $CHCl_3$. ^1H NMR (80 MHz, $CDCl_3$): δ 1.22 (3H, *d*, *J* = 6 Hz, Me-9), 1.87 (3H, d, *J* = 6 Hz, Me-9′), 2.71 (1H, *dd*, *J* = 13, 8.0 Hz, H-7), 3.10 (1H, *dd*, *J* = 14, 5.5 Hz, H-7), 3.78 (3H, *s*, OMe), 3.80 (6H, *s*, 2 × OMe), 3.83 (6H, *s*, 2 × OMe), 4.2–4.5 (1H, *m*, H-8), 6.05–6.25 (1H, *m*, H-8′), 6.2–6.5 (1H, H-7′), 6.43 (2H, *s*, H-2, H-6), 6.53 (2H, *s*, H-3′, H-5′). EIMS (probe) 70 eV, *m/z* (rel. int.): 402 $[M]^+$ (27), 211 (5), 210 (40), 209 (100), 208 (73), 195 (19), 194 (87), 193 (55), 192 (7), 191 (6), 182 (7), 181 (51), 179 (30), 178 (39), 177 (12), 169 (4), 168 (28), 167 (6), 166 (7), 165 (16), 164 (7), 163 (17), 162 (10), 161 (7), 153 (11), 151 (23), 150 (14), 149 (14), 148 (11), 147 (18), 138 (5), 137 (16), 136 (10), 135 (22), 134 (9), 133 (23), 131 (11), 125 (6), 123 (9), 122 (7), 121 (19), 120 (8), 119 (19), 118 (9), 115 (9), 109 (10), 107 (19), 105 (25), 103 (15), 95 (12), 93 (10), 91 (40), 85 (11), 83 (12), 81 (13), 79 (33), 78 (13), 77 (34), 71 (18), 70 (11), 69 (25).

Epi-sesartemin (**4**). 97 mg, mp 114–115° (from Et_2O). $C_{23}H_{28}O_8$ (found 430.1622 for 430.1628 by HR-MS). UV λ_{max}^{MeOH} nm (log ε): 270 (3.40), 235 sh (4.14), 210 (4.92). $[\alpha]_D^{25}$ +108° in $CHCl_3$. IR ν_{max}^{KBr} cm^{-1}: 2900, 2820, 1625, 1585, 1540, 1500, 1450, 1410, 1360, 1320, 1230, 1200, 1125, 1080, 1040, 1000, 925, 830. ^1H NMR: see Table 1. ^{13}C NMR: see Table 2. EIMS (probe) 70 eV, *m/z* (rel. int.): 430 $[M]^+$ (40), 249 (6), 233 (10), 224 (18), 219 (15), 209 (8), 208 (24), 207 (40), 206 (17), 205 (7), 203 (9), 197 (42), 196 (16), 195 (23), 194 (15), 192 (13), 191 (34), 182 (20), 181 (60), 180 (28), 179 (100), 178 (15), 177 (8), 176 (15), 175 (7), 169 (55), 168 (13), 167 (12), 166 (36), 165 (78), 161 (19), 154 (14), 153 (13), 152 (21), 151 (24), 139 (7), 138 (15), 133 (13), 125 (11), 115 (10), 95 (15), 93 (13), 91 (13), 81 (15), 79 (15).

Sesartemin (**5**). 36 mg, mp 115–116° (from Et_2O). $C_{23}H_{28}O_8$ (found 430.1627 for 430.1628 by HR-MS). UV λ_{max}^{MeOH} nm (log ε): 270 (4.11), 211 (4.83). $[\alpha]_D^{25}$ +50° in $CHCl_3$. ^1H NMR: see Table 1. ^{13}C NMR: see Table 2. EIMS (probe) 70 eV, *m/z* (rel. int.): 430 $[M]^+$ (47), 265 (5), 249 (9), 235 (7), 234 (8), 233 (11), 224 (18), 222 (6), 219 (17), 209 (7), 208 (24), 207 (51), 206 (15), 205 (8), 203 (11), 197 (36), 196 (21), 195 (38), 194 (21), 193 (10), 192 (14), 191 (46), 190 (9), 189 (9), 182 (23), 181 (72), 180 (33), 179 (100), 178 (22), 177 (11), 176 (19), 175 (9), 169 (42), 168 (15), 167 (12), 166 (35), 165 (89), 161 (26), 154 (10), 153 (18), 152 (26), 151 (26), 138 (11), 135 (11), 133 (16), 125 (13), 121 (8), 115 (11), 110 (10), 105 (10), 95 (18), 93 (15), 91 (15), 81 (18), 79 (15).

Epi-yangambin (**6**). 127 mg, mp 119–120° (from Et_2O). UV λ_{max}^{MeOH} nm (log ε): 272 (3.51), 238 sh (4.11), 210 (4.80). $[\alpha]_D^{25}$ +122° in $CHCl_3$. ^1H NMR: see Table 1. ^{13}C NMR: see Table 2. EIMS (probe) 70 eV, *m/z* (rel. int.): 446 $[M]^+$ (37), 265 (6), 250 (10), 249 (9), 235 (12), 224 (26), 223 (9), 219 (12), 208 (13), 207 (51), 206 (10), 197 (32), 196 (24), 195 (68), 194 (18), 191 (10), 189 (8), 182 (39), 181 (100), 179 (12), 177 (12), 176 (21), 169 (42), 168 (16), 167 (13), 166 (10), 165 (21), 154 (11), 153 (14), 151 (20), 138 (13), 125 (14), 110 (10), 95 (9), 93 (13), 91 (11), 81 (15), 79 (9).

Yangambin (**7**). 115 mg, mp 119–121° (from Et_2O). UV λ_{max}^{MeOH} nm (log ε): 270 (3.52), 235 (4.14), 210 (4.93). $[\alpha]_D^{25}$ +45.1° in $CHCl_3$. ^1H NMR: see Table 1. ^{13}C NMR: see Table 2. EIMS (probe) 70 eV, *m/z* (rel. int.): 446 $[M]^+$ (27), 265 (6), 250 (8), 249 (8), 235 (10), 224 (19), 223 (8), 219 (9), 208 (12), 207 (48), 206 (8), 197 (20), 196 (28), 195 (51), 194 (20), 193 (10), 191 (11), 190 (8), 189 (9), 182 (27), 181 (82), 179 (12), 177 (13), 176 (21), 169 (25), 168 (15), 167 (12), 166 (8), 165 (17), 163 (8), 154 (8), 153 (17), 152 (9), 151 (18), 149 (13), 145 (9), 138 (11), 137 (13), 136 (8), 135 (12), 131 (11), 128 (8), 125 (21), 123 (14), 121 (12), 119 (15), 117 (9), 115 (13), 111 (13), 110 (19), 109 (19), 107 (11), 105 (15), 97 (20), 96 (13), 95 (33), 93 (20), 91 (24), 85 (16), 83 (23), 82 (17), 81 (36), 79 (19).

Dihydrosesartemin (**8**). 21 mg. UV λ_{max}^{MeOH} nm (log ε): 282 (3.25), 232 sh (3.87), 218 (4.08). $[\alpha]_D^{25}$ +11.8° in $CHCl_3$. ^1H NMR (400 MHz, $CDCl_3$): δ 1.56 (1H, *br s*, exchangeable with D_2O, OH), 2.40 (1H, *m*, *J* = 5 Hz, H-3), 2.55 (1H, *dd*, *J* = 14, 11 Hz, $ArCH_2$), 2.73 (1H, *m*, H-4), 2.92 (1H, *dd*, *J* = 14, 5 Hz, $ArCH_2$), 3.73–4.08 (4H, H-5, CH_2OH), 3.83 (3H, *s*, OMe), 3.84 (6H, *s*, 2 × OMe), 3.89 (3H, *s*, OMe), 4.78 (1H, *d*, *J* = 6.3 Hz, H-2), 5.95 (2H, *s*, OCH_2O), 6.40 (2H, *s*, H-2′, H-6′), 6.53 (1H, *s*, H-2″ or H-6″), 6.54 (1H, *s*, H-2″ or H-6″). EIMS (probe) 70 eV, *m/z* (rel. int.): 432 $[M]^+$ (23), 414 (1.2), 383 (2.4), 368 (1.3), 353 (1.1), 249 (6), 233 (17), 224 (14), 219 (18), 208 (21), 207 (12), 206 (12), 195 (22), 193 (14), 183 (10), 182 (82), 181 (100), 180 (18), 179 (53), 169 (10), 167 (22), 166 (21), 165 (45), 153 (18), 152 (13), 151 (38), 148 (18), 137 (14), 136 (12), 123 (23), 105 (12), 95 (27), 93 (12), 91 (22), 79 (18).

β-Dihydroyangambin (**9**). 13 mg. UV λ_{max}^{MeOH} nm (log ε): 280 (3.75), 227 sh (4.25), 213 (4.58). $[\alpha]_D^{25}$ +15.1° in $CHCl_3$. ^1H NMR (400 MHz, $CDCl_3$): δ 1.78 (1H, *br s*, exchangeable with D_2O, OH), 2.03 (1H, *m*, *J* = 5 Hz, H-3), 2.52 (1H, *dd*, *J* = 14, 7 Hz,

$ArCH_2$), 2.8 (1H, *dd*, $J = 14$, 5 Hz, $ArCH_2$), 2.88 (1H, *m*, H-4), 3.70–4.05 (4H, *m*, H-5, CH_2OH), 3.84 (6H, *s*, 2 × OMe), 3.89 (6H, *s*, 2 × OMe), 3.94 (6H, *s*, 2 × OMe), 4.70 (1H, *d*, $J = 8.5$ Hz, H-2), 6.36 (1H, *s*, H-2″), 6.63 (1H, *s*, H-5″), 6.66 (2H, *s*, H-2′, H-6′). EIMS (probe) 70 eV, *m/z* (rel. int.): 448 $[M]^+$ (29), 399 (6), 265 (3), 263 (5), 249 (18), 240 (21), 235 (16), 233 (9), 224 (42), 223 (23), 222 (45), 221 (12), 219 (14), 210 (20), 208 (14), 207 (18), 205 (11), 198 (11), 197 (27), 196 (32), 195 (83), 193 (18), 191 (13), 189 (10), 183 (17), 182 (77), 181 (100), 179 (18), 177 (12), 176 (13), 169 (48), 168 (21), 167 (46), 165 (20), 161 (11), 154 (19), 153 (19), 152 (22), 151 (50), 149 (12), 148 (22), 139 (20), 138 (28), 137 (27), 136 (16), 135 (12), 133 (10), 125 (15), 124 (12), 123 (13), 122 (12), 121 (15), 110 (12), 109 (18), 107 (15), 106 (11), 105 (17), 95 (20), 93 (17), 92 (12), 91 (29), 81 (23), 79 (22).

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