Two New Sesterterpene Tetronic Acids from the Marine Sponge *Ircinia oros*[1]

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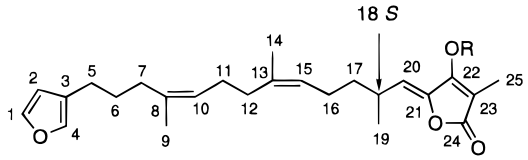
Two new sesterterpene tetronic acids, (8*Z*,13*Z*,18*S*,20*Z*)-strobilinin (**1**) and (7*E*,12*Z*,18*S*,20*Z*)-variabilin (**3**), together with the known compounds (7*E*,12*E*,18*S*,20*Z*)-variabilin (**5**), (7*E*,13*Z*,-18*S*,20*Z*)-variabilin (**7**), and (7*Z*,12*Z*,20*Z*)-variabilin (**9**), have been isolated from the sponge *Ircinia oros* as their 22-*O*-methyl derivatives **2**, **4**, **6**, **8**, and **10**. The structures of all compounds were determined by spectroscopic methods, mainly 1D and 2D NMR methodologies.

Sesterterpene tetronic acids are commonly encountered in sponges of the order Dictyoceratida (Demospongiae), mainly in the genera *Ircinia*, *Psammocinia*, and *Sarcotragus*, where they are reported to be of chemotaxonomic significance.[2,3]

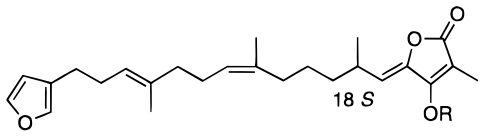
Variabilin, the first representative of a group of secondary metabolites termed variabilins, sesterterpene tetronic acids with a $\Delta^{7,8}$ double-bond, was first reported from the sponge *Ircinia variabilis* by Faulkner, in 1973, as an antimicrobial agent.[4] Sesterterpene tetronic acids of this type with a $\Delta^{8,10}$ double-bond are referred to as strobilinins; the basic structure of strobilinin without stereochemistry and double-bond geometry was first described by Rothberg and Shubiak from *Ircinia strobilina*.[5] In 1994, Davis and Capon showed that the originally described strobilinin[5] was in fact a mixture of two isomers, namely (8*E*,13*Z*,20*Z*)- and (8*Z*,13*E*,20*Z*)-strobilinin.[6] Several geometric, stereo-, and regioisomers of variabilin and strobilinin and other related types have been described to date[7−10] and shown to possess antiviral and cytotoxic activity.[10,11]

Our sample of *Ircinia oros* Schmidt 1864 was collected in Maltese waters, and its CH_2Cl_2 (DCM) and aqueous MeOH extracts are currently under evaluation for biological activities making use of high-throughput screening (HTS) in a multitude of assays. Concurrent with these assays, the secondary metabolite investigation of the sponge was started. To date, from the DCM extract of this sponge, two new (**1**, **3**) and three known (**5**, **7**, **9**) sesterterpene tetronic acids have been isolated as their 22-*O*-methyl derivatives (**2**, **4**, **6**, **8**, and **10**); **5**, **7**, and **9** are reported from this species for the first time.

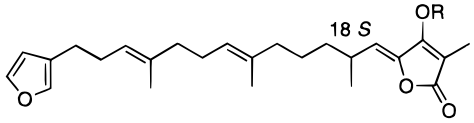
Freeze-dried sponge material was extracted with DCM and fractionated employing normal-phase vacuum−liquid chromatography (VLC). Chemical screening of the resultant fractions by ^{1}H NMR spectroscopy showed one of the fractions to contain resonances characteristic of sesterterpene tetronic acids. These compounds are known for their instability, especially in the presence of oxygen.[12] To avoid decomposition of these compounds, as well as to improve chromatographic behavior through prevention of keto−enoltautomerism, the fraction was methylated with diazomethane[13] and yielded a mixture of 22- and 24-OCH_3 derivatives.[14] Normal- and reversed-phase (C-18) HPLC of the 22-OCH_3 derivatives yielded compounds **2**, **4**, **6**, **8**, and **10**.



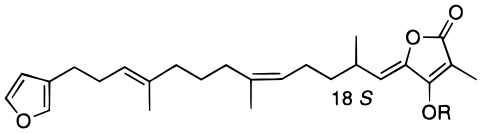
1 R=H, **2** R=CH_3



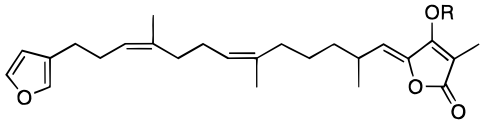
3 R=H, **4** R=CH_3



5 R=H, **6** R=CH_3



7 R=H, **8** R=CH_3



9 R=H, **10** R=CH_3

The molecular formula of **2** was established as $C_{26}H_{36}O_4$ by accurate mass measurement. ^{1}H NMR spectroscopic measurements revealed signals at δ 6.26 (br s), 7.21 (br s), and 7.34 (m) for a 3-substituted furan moiety, four resonances for methyl groups (δ 1.65 (d, J = 1 Hz), 1.67 (s), 1.03 (d, J = 6.5 Hz), and 2.06 (s)), a signal for a methoxyl function (δ 4.11 (s)), and three resonances for olefinic protons (δ 5.13 (m), 5.09 (t, J = 7.0 Hz), and 5.15 (d, J = 9.7 Hz)). These data, together with the observed UV maximum at 263 nm, IR absorptions at 1640 and 1760 cm^{-1} for carbon−carbon double-bonds, and a lactone moiety, suggested, when compared with literature data, that **2** was a sesterterpene tetronic

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acid.[5,8,10] After assignment of all protons to their directly bonded carbon atoms *via* a $^1H-^{13}C$ 2D NMR shift correlated measurement (HMQC), it was possible to deduce two major molecular fragments from the $^1H-^1H$ COSY spectrum of **2**. Thus, coupling was observed from H-1 (δ 7.34 (m)) to H-2 (δ 6.26 (br s)), H-2 to H-4 (δ 7.21 (br s)) and H-4 to H_2-5 (δ 2.39 (dd, J = 7.6, 8.1 Hz)). Further, H_2-5 coupled to H_2-6 (δ 1.63 (m)), which in turn coupled with H_2-7 (δ 2.05 (m)), clearly delineating the first molecular fragment, the furan moiety through to C-7. Coupling of H_3-19 (δ 1.03 (d, J = 6.5 Hz)) to H-18 (δ 2.77 (m)), H-18 to H-20 (δ 5.15 (d, J = 9.7 Hz)) and to H_2-17 (δ 1.37 (br m)), H_2-17 to H_2-16 (δ 1.94 (m)), and H_2-16 to H-15 (δ 5.09 (tq, J = 7.0, 1.0)), which further coupled to H_3-14 (q, J = 1.0 Hz), characterized a second major fragment of the molecule, C-20 to C-13. $^1H-^1H$ couplings from other proton resonances could not be interpreted unambiguously due to signal overlapping. A long-range $^1H-^{13}C$ 2D NMR shift-correlated measurement (HMBC) made with **2** permitted the molecule to be further elaborated. Thus, long-range couplings from C-21 (142.8 ppm) to H-20 and to H_3-25 (δ 2.06 (s)) and between C-22 (162.0 ppm) and H-20, the methoxyl protons (δ 4.11 (s)), and H_3-25, as well as between C-24 (171.0 ppm) and H_3-25 clearly established, together with the C-20 to C-13 fragment, the C-25 to C-13 part of **2**. Remaining to be accounted for were two methylene groups, CH_2-11 and CH_2-12, both with identical chemical shift in the ^1H NMR spectrum (δ 2.00 (m)) and a double bond (δ 5.13 (m)) substituted with a methyl group (1.67 (s)). Through detailed analysis of all homo- and heteronuclear NMR correlation spectra, it was evident that the two methylene groups are adjacent, as are H_2-11 and H-10. With the major part of the molecule established the C-9 to C-12 fragment had thus to be located between C-7 and C-13, giving rise to a the basic structure of a strobilinin derivative.

Depending on the geometry of double-bonds, methyl groups on isolated double bonds in sesterterpene tetronic acids show characteristic ^1H NMR chemical shifts: δ >1.6 for the *Z* and δ <1.6 for the *E* isomer, the corresponding ^{13}C NMR chemical shifts being >20 ppm and <20 ppm, respectively, for the equivalent carbon atoms.[8,10] Thus, ^1H NMR shifts of δ 1.65 and 1.67 for the H-14 and H-9 and δ 23.4 for C-9 and C-14 established the *Z* configuration at both $\Delta^{8,10}$ and $\Delta^{13,15}$. NOE difference measurements (600 MHz), with irradiation at the resonances for the olefinic protons (δ 5.1), led to the enhancement of the signals for both CH_3-9 and CH_3-14, clearly confirming the 8*Z*,13*Z* geometry of both $\Delta^{8,10}$ and $\Delta^{13,15}$. The geometry of $\Delta^{20,21}$ was also determined as *Z* by comparison of the ^{13}C chemical shifts for C-17 to C-23 with published data for (7*E*,12*E*,20*Z*)-22-*O*-methylvariabilin.[10]

The absolute configuration at C-18 in related sesterterpene tetronic acids was determined by degradation studies and shown to be *S* in (7*E*,12*E*,20*Z*)-variabilin from an *Amphimedon* sp. and *I. variabilis* and found to be *R* in (8*E*,13*Z*,20*Z*)- and (8*Z*,13*E*,20*Z*)-strobilinin.[15,16] Although literature data differ markedly, a negative optical rotation, e.g., −36° for 18*S* variabilin,[16] seems to be typical for the 18*S* isomers, with a positive rotation, e.g., +36° for 18*R* strobilinin acetates[16] for the 18*R* isomers. In the case of **2** an optical rotation of −43.7° suggests it to be 18*S*. Compound **2** is thus (8*Z*,13*Z*,18*S*,20*Z*)-22-*O*-methylstrobilinin, indicating **1** to be the new natural product (8*Z*,13*Z*,18*S*,20*Z*)-strobilinin.

Table 1. ^{13}C-NMR Data for Compounds **2**, **4**, and **6** (100 MHz, $CDCl_3$)

carbon	**2**	**4**	**6**
1	142.6 (d)[a]	142.5 (d)	142.5 (d)
2	110.9 (d)	111.1 (d)	111.1 (d)
3	125.1 (s)	125.0 (s)	125.0 (s)
4	138.7 (d)	138.8 (d)	138.8 (d)
5	24.7 (t)	25.0 (t)	25.0 (t)
6	28.3 (t)	28.4 (t)	28.4 (t)
7	31.4 (t)	123.8 (d)	123.7 (d)
8	135.0 (s)	135.7 (s)	135.7 (s)
9	23.4 (q)	16.0 (q)	16.0 (q)
10	125.2 (d)	39.9 (t)	39.5 (t)
11	26.3 (t)	26.4 (t)	26.5 (t)
12	32.1 (t)	125.0 (d)	124.3 (d)
13	135.3 (s)	135.1 (s)	134.9 (s)
14	23.4 (q)	23.3 (q)	15.8 (q)
15	124.9 (d)	31.7 (t)	39.7 (t)
16	25.8 (t)	25.7 (t)	25.7 (t)
17	37.5 (t)	36.9 (t)	36.7 (t)
18	30.7 (d)	30.9 (d)	30.8 (d)
19	20.6 (q)	20.7 (q)	20.7 (q)
20	115.1 (d)	115.1 (d)	115.2 (d)
21	142.8 (s)	142.7 (s)	142.7 (s)
22	162.0 (s)	162.0 (s)	162.0 (s)
23	99.0 (s)	99.1 (s)	99.0 (s)
24	171.0 (s)	171.0 (s)	171.1 (s)
25	8.6 (q)	8.6 (q)	8.5 (q)
OCH_3	58.8 (q)	58.8 (q)	58.8 (q)

[a] Multiplicity by DEPT, s = C, d = CH, t = CH_2, q = CH_3.

Compound **4** was shown by accurate mass measurement to have a molecular formula identical with that of **2**, $C_{26}H_{36}O_4$. The $^1H-^{13}C$ short-range (HMQC) spectrum of **4** permitted correlation of all proton and carbon resonances of directly bonded atoms. By comparing these NMR data of **4** with those for **2** (see Tables 1 and 2), it was evident that the C-16 to C-25 part of **4** was identical to that of **2**. Strobilinin derivatives such as **2** show characteristic chemical shifts for the C-5 and C-6 methylene groups in their ^1H NMR spectra at δ 2.4 and 1.6, whereas these protons in variabilins resonate at δ 2.4 and 2.2 (Table 2). The characteristic ^1H NMR chemical shifts for the methylene groups H_2-5 and H_2-6 at δ 2.45 (dd, J = 7.1, 7.6 Hz) and δ 2.24 (ddd, J = 7.1, 7.1, 7.6 Hz), respectively, thus suggested **4** to be, in contrast to **2**, a variabilin derivative. $^1H-^1H$ COSY and $^1H-^{13}C$ heteronuclear long-range (HMBC) measurements established the connectivities between H_2-5 and H_2-6 and between H_2-6 and C-7. From the $^1H-^1H$ COSY it was also clear that H-7 coupled with H_3-9 (δ 1.58 (s)), the resonance of which showed a cross peak to C-10 (39.9 ppm) in the HMBC spectrum. C-10 in turn had an HMBC correlation to H-12 (δ 5.08 (br t, J = 6.1 Hz)), which further coupled to H_2-11 (δ 2.00 (m)) and H_3-14 (δ 1.64 (s)). From H_3-14, heteronuclear coupling to C-13 (135.1 ppm) and to C-15 (31.7 ppm) was seen in the HMBC spectrum. H-15 (δ 2.00 (m)) then coupled to H_2-16 (1.35 (m)), as is evidenced by the relevant cross-peaks in the $^1H-^1H$ COSY of **4**. The geometry of the double bonds was determined as outlined for **2**. Chemical shifts of δ 1.58 for H_3-9 and of 16.0 ppm for C-9 and δ 1.64 for H_3-14 and 23.3 ppm for C-14 suggested the 7*E*,12*Z* configuration. This was confirmed by NOE difference measurements: irradiation at δ 5.16 (H-7) did not affect the intensity of the signal for H_3-9, whereas irradiation at δ 5.08 resulted in an enhance-

Table 2. ^{1}H-NMR Data for Compounds **2**, **4**, and **6** (ppm, $CDCl_3$, 600 MHz for Compound **2**, 400 MHz for Compounds **4** and **6**)[a]

carbon	2	4	6
1	7.34 (m)	7.33 (br s)	7.33 (br s)
2	6.26 (br s)	6.27 (br s)	6.27 (br s)
4	7.21 (br s)	7.21 (br s)	7.20 (br s)
5	2.39 (dd, J = 7.6, 8.1 Hz)	2.45 (dd, J = 7.1,7.6 Hz)	2.44 (t, J = 7.6 Hz)
6	1.63 (m)	2.24 (ddd, J = 7.1, 7.1, 7.6 Hz)	2.24 (ddd, J = 7.1, 7.1, 7.6 Hz)
7	2.05 (m)	5.16 (t, J = 7.1 Hz)	5.16 (m)
9	1.67 (s)	1.58 (s)	1.58 (s)
10	5.13 (m)	2.00 (m)	1.99 (m)
11	2.00 (m)	2.00 (m)	2.06 (m)
12	2.00 (m)	5.08 (br t, J = 6.1 Hz)	5.07 (br t, J = 6.6 Hz)
14	1.65 (d, J = 1.0 Hz)	1.64 (s)	1.55 (s)
15	5.09 (tq, J = 7.0, 1.0 Hz)	2.00 (m)	1.94 (m)
16	1.94 (m)	1.35 (m)	1.35 (m)
17	1.37 (br m)	1.35 (m)	1.35 (m)
18	2.77 (m)	2.77 (m)	2.76 (m)
19	1.03 (d, J = 6.5 Hz)	1.04 (d, J = 6.6 Hz)	1.03 (d, J = 6.6 Hz)
20	5.15 (d, J = 9.7 Hz)	5.15 (d, J = 9.7 Hz)	5.15 (d, J = 10.2 Hz)
25	2.06 (s)	2.06 (s)	2.06 (s)
OCH_3	4.11 (s)	4.11 (s)	4.11 (s)

[a] All assignments are based on extensive 1D and 2D NMR experiments, including COSY90, HMQC, and HMBC.

ment of the ^{1}H NMR signal of H_3-14. On the basis of almost identical ^{13}C NMR chemical shifts of compounds **2** and **4** in the region of the tetronic acid moiety, it was concluded that **4** also has the 20*Z*-configuration. The optical rotation of **4** (−33.1°) suggested the absolute configuration at C-18 to be *S* on the same grounds as discussed for **2**. Thus, compound **4** is (7*E*,12*Z*,18*S*,20*Z*)-22-*O*-methylvariabilin, indicating **3** to be the new natural product (7*E*,12*Z*,18*S*,20*Z*)-variabilin.

Compounds **6**, **8**, and **10** were identified as the 22-*O*-methyl derivatives of (7*E*,12*E*,18*S*,20*Z*)-variabilin (**5**), (7*E*,13*Z*,18*S*,20*Z*)-variabilin (**7**), and (7*Z*,12*Z*,20*Z*)-variabilin (**9**) by comparison of their ^{1}H and ^{13}C NMR spectroscopic data and their optical rotations with published values.[8,10]

Recently, five sesterterpene tetronic acid acetates, derivatives of (8*Z*,13*Z*,20*Z*)-strobilinin, (7*Z*,13*Z*,20*Z*)-felixinin, (8*E*,13*Z*,20*Z*)-strobilinin, (7*E*,13*Z*,20*Z*)-felixinin and (7*E*,12*E*,20*Z*)-variabilin, have been reported from *Ircinia felix*, *I. strobilina* and *I. campana* from the Colombian Caribbean.[7] Despite derivatization, only one of the compounds was obtained in pure form; the others were analyzed as mixtures. In this work, the C-18 was tentatively assigned as having the *R* absolute configuration on the basis of the optical rotations recorded from the mixtures (ratio 1:1), +34.8° and +45.6°, respectively. This assignment may indeed be correct since the stereo- and regiochemistry of the carbon−carbon double bonds and/or methylation or acetylation of the tetronic acid moiety appears to have only a modest affect on the optical rotation of this class of compounds.[15,16] Compound **1** of the present study has the same basic structure as (8*Z*,13*Z*,18*R*,20*Z*)-strobilinin acetate isolated by Martinez *et al*. as part of a mixture.[7] Optical rotation comparisons, however, indicated **1** to be the enantiomer of (8*Z*,13*Z*,18*R*,20*Z*)-strobilinin.

Prior to methylation, the tetronic acids containing fraction, was assessed for its cytotoxicity and antiplasmodial activity[17,18] and found to be inactive. The DCM and aqueous MeOH extracts of the sponge were also tested for their HIV-1 reverse transcriptase inhibitory activity,[19] and found to have no positive effects. In order to allow the biological activity of the methylated substances to be assessed in HTS they were not hydrolyzed to yield the natural products. The results of the biological activity assessment of compounds **2**, **4**, **6**, **8**, and **10** will be reported elsewhere.

Experimental Section

General Experimental Procedures. Reversed-phase HPLC was carried out using a Merck-Hitachi system equipped with a L-6200A Intelligent Pump, a L-4500A diode array detector, a D-6000A interface with D-7000 HSM software, a Rheodyne 7725i injection system, and a Knauer Spherisorb S ODS 2 column (5 μm, 250 × 8 mm). All other details as per ref 20.

Animal Material. The sponge samples were collected by SCUBA diving at a depth of 3 m. The sponge was identified as *I. oros* Schmidt 1864 by Dr. Ruth Desqueyroux-Faundez, Musée d'Histoire Naturelle, Geneva, Switzerland. A voucher specimen has been deposited at Musée d'Histoire Naturelle, Geneva, Switzerland, voucher no. CT912J.

Extraction and Isolation. Frozen sponge tissue was freeze-dried (88.0 g) and extracted with DCM (5 × 1 L) to give 2.0 g of a brown oil. After fractionation by normal-phase VLC (gradient hexane/EtOAc/MeOH), the sesterterpene tetronic acid-containing fraction was methylated using diazomethane.[13] The methylated fraction (250 mg) was separated by reversed-phase (RP) (C-18) VLC (MeOH), followed by normal-phase HPLC (EtOAc/hexane (1/4)), to give 173 mg of the 22-OCH_3 and 50 mg of 24-OCH_3 derivatives. The 22-OCH_3 derivatives were further purified using RP (C-18) HPLC (CH_3CN/MeOH/H_2O (42/43/15), photodiode array detection 210−400 nm) to give **6** (44.4 mg), and two mixtures. The latter were separated using RP (C-18) HPLC (MeOH/H_2O (83/17), flow rate 2 mL/min, photodiode array detection 210−400 nm) to yield **2** (4.1 mg), **4** (7.0 mg), **8** (8.7 mg) and 3.0 mg of a mixture containing **10** and another unidentified sesterterpene tetronic acid.

(8*Z*,13*Z*,18*S*,20*Z*)-22-*O*-Methylstrobilinin (**2**): colorless oil (4.1 mg, 0.005%); $[\alpha]^{20}_D$ −43.7° (*c* 0.4, $CHCl_3$); UV (EtOH) λ_{max} 263 nm (ϵ 19 900); IR (film) ν_{max} 2927, 1760, 1640, 1453, 1356, 1060, 982 cm^{-1}; ^{1}H and ^{13}C NMR data see Tables 1 and 2; EIMS *m*/*z* $[M]^+$ 412 (6), 397 (1), 223 (13), 205 (10), 167 (17), 149 (100), 135 (19), 111 (16),109 (10); HREIMS 412.261 (calcd for $C_{26}H_{36}O_4$, 412.261).

(7*E*,12*Z*,18*S*,20*Z*)-22-*O*-Methylvariabilin (**4**): colorless oil (7.0 mg, 0.008%); $[\alpha]^{20}_D$ −33.1° (*c* 0.7, $CHCl_3$); UV

(EtOH) λ_{max} 263 nm (ϵ 12 100); IR (film) ν_{max} 2926, 1759, 1638, 1451, 1356, 1060, 1028, 981 cm^{-1}; ^1H and ^{13}C NMR data see Tables 1 and 2; EIMS *m/z* $[M]^+$ 412 (24), 397 (7), 331 (3), 318 (4), 207 (15), 204 (19), 193 (24), 181 (33), 167 (100), 149 (42), 141 (61), 135 (60), 123 (46), 109 (34), 81 (80); HREIMS 412.261 (calcd for $C_{26}H_{36}O_4$, 412.261).

(7*E*,12*E*,18*S*,20*Z*)-22-*O*-Methylvariabilin (**6**): colorless oil (44.4 mg, 0.05%); $[\alpha]^{20}_D$ −40.8° (*c* 0.7, $CHCl_3$); ^1H and ^{13}C NMR data see Tables 1 and 2; EIMS *m/z* $[M]^+$ 412 (44), 397 (12), 331 (7), 203 (26), 181 (38), 174 (34), 167 (96), 149 (42), 141 (52), 136 (74), 135 (70), 123 (55), 109 (30), 81 (100); UV, IR, and ^1H and ^{13}C NMR data are in agreement with literature values.[10]

(7*E*,13*Z*,18*S*,20*Z*)-22-*O*-Methylvariabilin (**8**): colorless oil (8.7 mg, 0.01%); $[\alpha]^{20}_D$ −47.2° (*c* 0.9 $CHCl_3$); UV (EtOH) λ_{max} 263 nm (ϵ 13 600); IR (film) ν_{max} 2926, 1760, 1640, 1453, 1356, 1060, 982 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 1.04 (3H, d, J = 7.1 Hz, H-19), 1.40 (4H, m, H-11/17), 1.58 (3H, s, H-9), 1.66 (3H, d, J = 1.5 Hz H-14), 1.94 (6H, m, H-10/12/16), 2.06 (3H, s, H-25), 2.24 (2H, ddd, J = 7.1, 7.1, 7.6 Hz, H-6), 2.45 (2H, dd, J = 7.1, 7.6 Hz, H-5), 2.78 (1H, m, H-18), 4.11 (3H, s, OCH_3), 5.09 (1H, dd, J = 6.6, 7.1 Hz, H-15), 5.16 (1H, m, H-7), 5.16 (1H, d, J = 10.2 Hz, H-20), 6.27 (1H, br s, H-2), 7.21 (1H, br s, H-4), 7.33 (1H, t, J = 1.5 Hz, H-1); ^{13}C NMR (100 MHz, $CDCl_3$) δ 8.6 (q, C-25), 15.9 (q, C-9), 20.6 (q, C-19), 23.4 (q, C-14), 25.1 (t, C-5), 25.7 (t, C-16), 26.3 (t, C-11), 28.4 (t, C-6), 30.7 (d, C-18), 31.4 (t, C-12), 37.5 (t, C-17), 39.6 (t, C-10), 58.8 (q, OCH_3), 99.0 (s, C-23), 111.1 (d, C-2), 115.1 (d, C-20), 123.7 (d, C-7), 124.6 (d, C-15), 125.0 (s, C-3), 135.7[a] (s, C-13), 135.8[a] (s, C-8), 138.8 (d, C-4), 142.5 (d, C-1), 142.8 (s, C-21), 162.0 (s, C-22), 171.0 (s, C-24), [a]assignments may be interchanged; EIMS *m/z* $[M]^+$ 412 (35), 397 (13), 331 (10), 318 (10), 208 (44), 207 (43), 203 (44), 181 (38), 167 (81), 141 (39), 135 (86), 122 (38), 109 (33), 81 (100). The spectroscopic data are consistent with literature values for the unmethylated[10] and acetylated[7] compounds.

(7*Z*,12*Z*,20*Z*)-22-*O*-Methylvariabilin (**10**): colorless oil (approximately 0.005%); ^{13}C NMR (100 MHz, $CDCl_3$) δ 8.6 (q, C-25), 20.7 (q, C-19), 23.3 (2xq, C-9 and 14), 25.3 (t, C-6), 25.8 (t, C-16), 26.3 (t, C-11), 28.3 (t, C-5), 30.9 (d, C-18), 31.6 (t, C-15), 32.3 (t, C-10), 37.0 (t, C-17), 58.8 (q, OCH_3), 99.1 (s, C-23), 111.1 (d, C-2), 115.1 (d, C-20), 124.0 (d, C-7), 124.6 (d, C-12), 125.0 (s, C-3), 135.2 (s, C-13), 135.8 (s, C-8), 138.8 (d, C-4), 142.5 (d, C-1), 142.8 (s, C-21), 162.0 (s, C-22), 171.0 (s, C-24). These data are consistent with literature values for the unmethylated compound.[8]

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References and Notes

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