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Secondary metabolites from the liverwort *Jamesoniella colorata*

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Dedicated to Professor Eicher on the occasion of his 70th birthday

Abstract

Six new labdane type diterpenoids, three *seco*-clerodane diterpenoids, jamesoniellide I, along with the two new jamesoniellides K and L, the sesquiterpene waitziacuminone and a new chlorinated bisbibenzyl, 6,6′,10,10′,12,12′-hexachloroisoperrottetin A, have been isolated from the liverwort *Jamesoniella colorata*. Their structures were elucidated by NMR spectroscopy. The absolute configuration of 3-oxo-labda-8(17),13(16),14-triene (1) was established by CD spectroscopy.

Keywords: *Jamesoniella colorata*; Bryophyte; Liverwort; Labdanes; *seco*-Clerodanes; Jamesoniellides; Waitziacuminone; Chlorinated bisbibenzyl

1. Introduction

Liverworts are known to be a rich source of terpenoids and phenolic compounds (Huneck, 1983; Zinsmeister et al., 1991; Asakawa, 1995, 2001). In the course of our investigation on *Jamesoniella* species (Blechschmidt and Becker, 1992; Tazaki et al., 1995, 1998, 1999) we have analyzed the constituents of the species *Jamesoniella colorata*. This paper describes the isolation and characterization of six new labdane type diterpenoids, three *seco*-clerodane diterpenoids, jamesoniellide I along with the two new jamesoniellides K and L, the sesquiterpene waitziacuminone and a new chlorinated bisbibenzyl (Fig. 4).

2. Results and discussion

A combination of size exclusion chromatography, vacuum liquid chromatography and HPLC of the dichloromethane extract of the plant led to the isolation of the six new labdane-type diterpenoids 3-oxo-labda-8(17),13(16),14-triene (**1**), 3,11-dioxo-labda-8(17),13(16),14-triene (**2**), 3α-hydroxy-11-oxo-labda-8(17),13(16),14-triene (**3**), 3β-hydroxy-11-oxo-labda-8(17),13(16),14-triene (**4**), 3β-hydroxy-labda-8(17),13(16),14-triene (**5**), 11-hydroxy-3-oxo-labda-8(17),13(16),14-triene (**6**) and a previously known sesquiterpene ketone, waitziacuminone (**7**) (Jakupovic et al., 1989).

The ethyl acetate soluble phase of the methanol extract afforded three diterpenoids with *seco*-clerodane skeleton, jamesoniellide I (**8**) (Tazaki et al., 1999) and the new jamesoniellides K (**9**) and L (**10**), together with a new chlorinated bisbibenzyl, 6,6′,10,10′,12,12′-hexachloroisoperrottetin A (**11**). Their structures were deduced from NMR and mass spectral data.

Compound **1** was obtained as a yellow oil with a molecular peak m/z 286 $[M]^+$ in the EI mass spectrum which is in agreement with the molecular formula $C_{20}H_{30}O$. The ^{13}C NMR spectrum (Table 1) contained the signals of three methyls, nine methylenes, three methines and five quaternary carbons indicating three double bonds (δ_C 147.5, 146.8, 139.0, 115.7, 113.3, 107.5) and one carbonyl group at δ_C 216.7. The ^1H NMR spectrum contained the signals for three tertiary methyl groups (δ_H 1.07, 1.00, 0.83), along with three exomethylene groups (δ_H 5.18, 5.03, 4.98, 4.94, 4.91, 4.62). The similarity of the spectroscopic data to sclarene (Perry and Weavers, 1985) and isoraimonol (Noma et al., 1982) showed that **1** was a labdane diterpenoid. The location of the carbonyl group at C-3 could be deduced from the HMBC spectrum. The relative configuration of **1** could be determined from NOESY correlations of H-18 to H-5, H-5 to H-9 and H-19 to H-20 (Fig. 1). In the CD spectrum, a negative Cotton effect

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Table 1
^{13}C NMR spectral data of compounds **1–6**, **9** and **10**

C	1	2	3	4	5	6	9	10
C-1	37.5 *t*	36.7 *t*	36.6 *t*	31.2 *t*	37.0 *t*	37.6 *t*	27.6 *t*	27.6 *t*
C-2	34.7 *t*	34.4 *t*	27.6 *t*	25.7 *t*	27.9 *t*	34.7 *t*	22.2 *t*	22.2 *t*
C-3	216.7 *s*	215.4 *s*	78.8 *d*	75.9 *d*	78.8 *d*	216.6 *s*	138.9 *d*	138.9 *d*
C-4	47.7 *s*	47.7 *s*	39.2 *s*	37.6 *s*	39.1 *s*	47.7 *s*	132.2 *s*	132.2 *s*
C-5	55.2 *d*	54.7 *d*	54.1 *d*	47.9 *d*	54.6 *d*	55.9 *d*	45.9 *s*	45.9 *s*
C-6	25.1 *t*	24.0 *t*	23.3 *t*	23.3 *t*	24.0 *t*	24.9 *t*	89.0 *d*	89.0 *d*
C-7	37.9 *t*	36.0 *t*	36.6 *t*	36.8 *t*	38.2 *t*	38.8 *t*	43.6 *t*	43.6 *t*
C-8	147.5 *s*	143.8 *s*	144.4 *s*	144.8 *s*	148.0 *s*	144.5 *s*	121.7 *s*	121.7 *s*
C-9	55.5 *d*	64.8 *d*	66.1 *d*	66.4 *d*	56.3 *d*	59.0 *d*	153.0 *s*	153.0 *s*
C-10	39.2 *s*	38.9 *s*	39.6 *s*	39.7 *s*	39.1 *s*	39.6 *s*	69.8 *d*	69.8 *d*
C-11	22.8 *t*	207.4 *s*	207.6 *s*	207.9 *s*	22.4 *t*	68.6 *d*	33.6 *t*	33.6 *t*
C-12	30.2 *t*	48.7 *t*	49.2 *t*	49.3 *t*	30.2 *t*	39.0 *t*	71.3 *d*	71.3 *d*
C-13	146.8 *s*	139.1 *s*	140.0 *s*	140.0 *s*	147.0 *s*	143.7 *s*	145.5 *s*	169.5 *s*
C-14	139.0 *d*	137.9 *d*	138.2 *d*	138.2 *d*	139.0 *d*	138.3 *d*	148.0 *d*	119.0 *d*
C-15	113.3 *t*	115.1 *t*	115.1 *t*	114.9 *t*	113.2 *t*	144.3 *t*	99.9 *d*	172.0 *s*
C-16	115.7 *t*	120.0 *t*	119.8 *t*	119.9 *t*	115.5 *t*	118.6 *t*	171.0 *s*	99.5 *d*
C-17	107.5 *t*	109.8 *t*	109.2 *t*	109.0 *t*	106.7 *t*	111.2 *t*	171.2 *s*	171.0 *s*
C-18	26.0 *q*	25.5 *q*	28.3 *q*	28.4 *q*	28.3 *q*	25.8 *q*	171.7 *s*	171.7 *s*
C-19	21.7 *q*	21.7 *q*	15.4 *q*	22.2 *q*	15.4 *q*	21.8 *q*	28.9 *q*	28.9 *q*
C-20	14.1 *q*	13.8 *q*	14.5 *q*	14.3 *q*	14.5 *q*	15.8 *q*	17.9 *q*	17.9 *q*

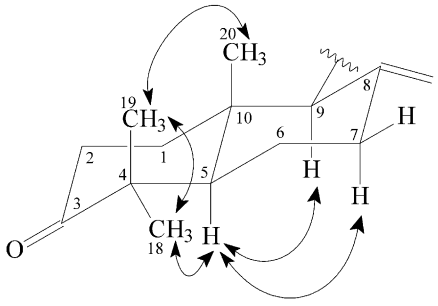

Fig. 1. Significant NOESY couplings of compound **1**.

was observed at 210 nm. Application of the octant rule led to the presence of a labdane skeleton instead of an enantiomeric *ent*-labdane skeleton. Thus, **1** should be 3-oxo-labda-8(17),13(16),14-triene.

Compound **2** was obtained as a yellow oil with the molecular formula $C_{20}H_{28}O_2$ as indicated by the EI mass spectrum (*m*/*z* 300 $[M]^+$). Both, the ^{1}H and ^{13}C NMR were very similar to that of compound **1**. In contrast to **1**, the ^{13}C NMR spectrum (Table 1) showed the presence of an additional carbonyl group at δ_C 207.4. The significant low field shift of H-9 (δ_H 3.01) and H-12 (δ_H 3.22, 3.15) in the ^{1}H NMR spectrum together with the ^{1}H and ^{13}C assignments by ^{1}H–^{1}H COSY, HSQC, NOESY and HMBC (Fig. 2) spectra confirmed the structure of the labdane derivative **2** as 3,11-dioxo-labda-8(17),13(16),14-triene.

Compound **3**, a colourless oil, was assigned the molecular formula $C_{20}H_{30}O_2$ (EIMS, *m*/*z* 302 $[M]^+$). Again, the ^{1}H and ^{13}C spectra displayed the characteristic signals of the labdane skeleton with three tertiary methyl groups and three exomethylene groups. The ^{13}C NMR spectrum (Table 1) was similar to that of compound **2** but differed in the absence of the carbonyl function at position C-3. Instead, a signal for an oxygenated aliphatic carbon at δ_C 78.8 with a corresponding proton at δ_H 3.25 appeared, indicating a hydroxyl moiety at position C-3. The stereochemistry at C-3 could be deduced from the coupling pattern of H-3, which showed an *ae* coupling to H-2α ($J_{3\alpha/2\alpha}$ = 5.0 Hz) and an *aa* coupling to H-2β ($J_{3\alpha/2\beta}$ = 10.5 Hz). Therefore, **3** is 3β-hydroxy-11-oxo-labda-8(17),13(16),14-triene.

Compound **4** differed from compound **3** only by the configuration at C-3. The ^{1}H NMR spectrum displayed the signal of the methine proton H-3β at δ_H 3.42 with $J_{3\beta,2\alpha}$ = 3.8 and $J_{3\beta,2\beta}$ = 3.8. The stereochemistry at C-3 was supported by the γ-effect of the axial hydroxyl group affecting C-1 and C-5 as shown in the ^{13}C NMR spectrum (Table 1). The 2D NMR spectra confirmed the structure of **4** as 3α-hydroxy-11-oxo-labda-8(17),13(16),14-triene.

Compound **5** was obtained as a yellow oil. The $[M]^+$ ion at *m*/*z* 288 was in agreement with the molecular formula $C_{20}H_{32}O$. The ^{13}C NMR spectrum showed the signals of three methyls, nine methylenes, four methines and four quaternary carbons and was very similar to that of compound **3** (Table 1), except from the absence of a carbonyl function at C-11. The significant high field shift of H-9 (δ_H 1.58) and H-12 (δ_H 2.34 and 1.99) in the ^{1}H NMR spectrum along with the ^{1}H and ^{13}C assignments by ^{1}H–^{1}H COSY, HSQC and HMBC confirmed the structure of compound **5** as 3β-hydroxy-labda-8(17),13(16),14-triene.

The ^{1}H NMR spectrum of **6**, $C_{20}H_{30}O_2$ (EIMS, *m*/*z* 302 $[M]^+$), displayed signals due to the decalin moiety

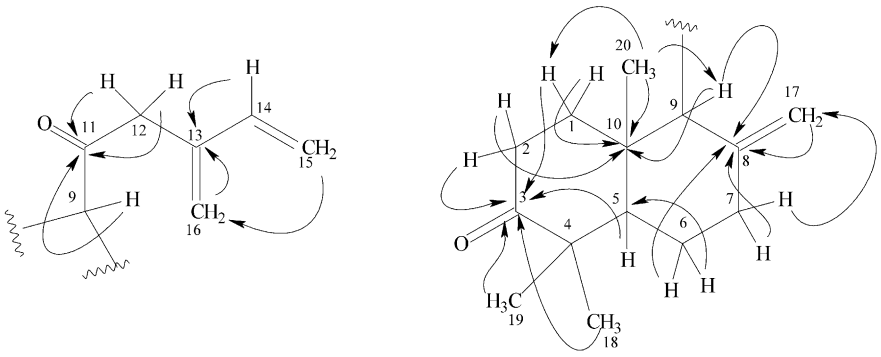

Fig. 2. Significant HMBC couplings of compound **2**.

of **2**. Furthermore, the ^{13}C spectrum was very similar to that of compound **2** but lacked a second carbonyl carbon (Table 1). Instead of it, the ^{13}C NMR spectrum revealed an oxygenated aliphatic carbon at δ_C 68.6 with the corresponding proton at δ_H 4.21. The location of the hydroxyl moiety at C-11 could be deduced from the ^1H–^1H COSY spectrum. Thus, compound **6** is 11-hydroxy-3-oxo-labda-8(17),13(16),14-triene. The absolute configuration at C-11 could not be elucidated as the compound decomposed.

Compounds **7** and **8** were identified as the previously known waitziacuminone (**7**) (Jakupovic et al., 1989) and jamesoniellide I (**8**) (Tazaki et al., 1999) by comparison of their physical and spectral data.

The molecular formula of compound **9** was found to be $C_{20}H_{22}O_8$ (EIMS, *m/z* 390 $[M]^+$). Its ^1H and ^{13}C NMR spectra indicated the presence of an analogue of 8 in which the furan ring was replaced by a 16,15-γ-butenolide moiety, which was substituted at C-15 with a hydroxyl group. The H–H-COSY, HSQC and HMBC spectra supported the structure, further NOESY experiments indicated the same stereochemistry at the other stereocentres as found in **8**, but gave no information about the orientation of the hydroxyl group at C-15.

The ^1H and ^{13} C NMR data of **10** were very similar to those of compound **9**. However, the ^1H NMR showed a significant high field shift of H-14 (δ_H 6.09). This suggested the presence of a 16-hydroxy-13-ene-15,16-olide moiety in **10**, which could be proved by comparison of the ^1H NMR data from related lactone derivatives (Jaensch et al., 1990).

Compound **11** was obtained as a white powder, whose molecular formula, $C_{28}H_{20}O_4Cl_6$ was established by DCI mass spectrometry. The mass spectrum of the molecular ion peaks showed the typical isotope pattern (630:632:634:636:638:640 = 65:100:70:35:6:1) for six chlorine atoms. The ^1H NMR showed the signals of four aromatic protons at δ_H 7.20 (*d*, *J* = 1.9), 7.15 (*d*, *J* = 8.2), 6.83 (*d*, *J* = 1.9) and 6.66 (*d*, *J* = 8.2), along with two benzylic methylene signals at δ_H 2.98 and 2.83. The ^{13}C NMR spectrum displayed the signals of the two benzylic methylene signals at δ_C 35.4 and 34.7 together with four methines and eight quaternary carbons. Since the molecular formula was established to be $C_{28}H_{20}O_4Cl_6$, it was evident that compound **11** was a symmetric dimer of a bibenzyl derivative. The substitution pattern of the hydroxyl groups and the position of the chlorine atoms was deduced from the HMBC spectra (Fig. 3). The ^1H–^1H COSY and NOESY spectra confirmed the structure of **11** as 6,6′,10,10′,12,12′-hexachloroisoperrottetin A.

Halogenated natural products are mainly known from marine organisms, fungi and higher plants (Gribble, 1996). Only a few halogenated structures, especially chlorinated bisbibenzyls, have been isolated from liverworts so far (Anton et al., 1997; Martini at al., 1998; Hashimoto et al., 2000). It is always a point of discussion whether halometabolites detected in any living organisms are genuine metabolites of that organism. It

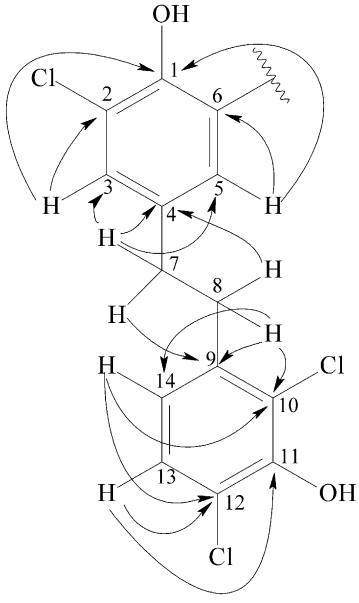

Fig. 3. Significant HMBC couplings of compound **11**.

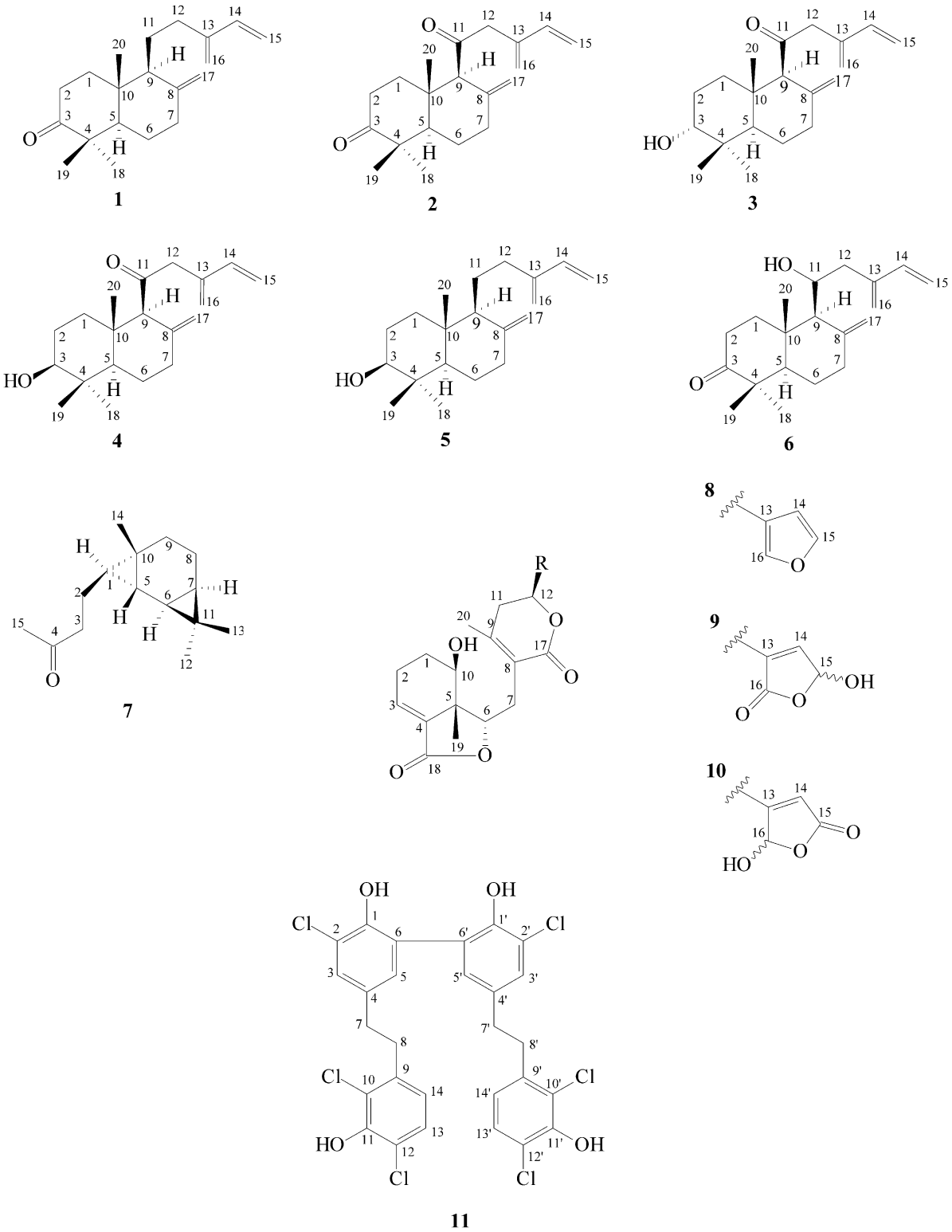

Fig. 4. Structures of compounds **1**–**11**.

is well accepted that the halogenated compounds isolated from marine invertebrates in many cases originate from incorporation of algae food. For plant materials exo- or even endosymbiotic fungi could be producers of halometabolites—especially when very small amounts are detected (Sakai et al., 1988). Halogen containing compounds even may be an artefact of isolation procedures (Hashimoto et al., 1989). In the case of *Bazzania trilobata*, Speicher et al. (2001) have shown, that the chlorinated compounds are not artefacts of

an incidental occurrence or of the sample preparation but are genuine and produced by the liverwort or an endosymbiotic fungi. The isolation of compound **11** was the first report of a bisbibenzyl and furthermore that of a chlorinated compound in the genus *Jamesoniella*.

3. Experimental

3.1. Spectroscopy and spectrometry

Optical rotations were measured in $CHCl_3$. CD spectra were recorded in *n*-hexane. NMR spectra were recorded in $CDCl_3$ and MeOH-d_4 (^{1}H NMR: 500 MHz, ^{13}C NMR: 125 MHz) relative to $CDCl_3$ at δ_H 7.24, δ_C 77.0, MeOH-d_4 at δ_H 3.30, δ_C 49.0, respectively. ^{13}C multiplicities were determined using the DEPT pulse sequence. 2D spectra were recorded as COSY, HSQC and HMBC experiments.

3.2. Plant material

J. colorata (Lehm.) Schiffn. was collected near Puerto Cisnes, Aisén, Chile, in March 1997 and identified by Professor Dr. R. Mues and Professor Dr. U. Drehwald. A voucher specimen is deposited at the Herbarium Drehwald (No. 3284).

3.3. Extraction and isolation

The extraction scheme followed the standard procedure of our group (Adam et al., 1998). The plant material (240 g) was powdered and extracted with CH_2Cl_2 to yield the non polar compounds, followed by MeOH. After removal of the CH_2Cl_2, the crude extract, which contained higher amounts of chlorophyll and other by-products, was chromatographed by CC on Sephadex LH-20 (150×2.5 cm i.d.) with MeOH:CH_2Cl_2 (1:1) as eluent, to give two fractions (I and II). Fraction II (4.2 g) was separated by VLC (silica gel 15 μm, 60×35 mm i.d., stepwise with a *n*-hexane–EtOAc gradient) and gave the fractions II-1 (0% EtOAc, 50 mg), II-2 (0.5–1% EtOAc, 183 mg), II-3 (1–4.5% EtOAc, 780 mg), II-4 (4.5–8% EtOAc, 243 mg), II-5 (9–14% EtOAc, 117 mg), II-6 (14–16% EtOAc, 385 mg), II-7 (20–70% EtOAc, 499 mg) and II-8 (70–100% EtOAc, 866 mg). Fr. II-2, II-3, II-4, II-5 and II-6 were further purified by HPLC on silica gel (LiChrospher Si 60, 5 μm, 4×250 mm). Sepn. of fr. II-2 (*n*-hexane:EtOAc, 98:2) yielded **7** (8 mg), sepn. of fr. II-3 (*n*-hexane:EtOAc, 93:7) gave **1** (55 mg) and **2** (175 mg), sepn. of fr. II-4 (*n*-hexane:EtOAc, 91.5:8.5) resulted in the isolation of **5** (40 mg), sepn. of fr. II-5 (*n*-hexane:*tert*.butyl methyl ether, 88:12) yielded **3** (40 mg) and **4** (45 mg), sepn. of fr. II-6 (*n*-hexane:EtOAc, 89:11) gave **6** (39 mg).

The methanolic extract was concd in vacuo and partionated between EtOAc and H_2O. The concd. organic layer (2.2 g) was chromatographed by CC on Sephadex LH-20 (150×2.5 cm i.d.) with MeOH:CH_2Cl_2 (80:20) as mobile phase to yield four fractions (fr. I–V). Fr. II and III were further purified by HPLC on diol modified silica gel (LiChrospher Diol, 5 μm, 4×250 mm). Sepn. of fr. II (*n*-hexane:EtOAc, 65:35) yielded **8** (15 mg), sepn. of fr. III (*n*-hexane:EtOAc, 52:48) gave **9** (24 mg) and **10** (9 mg). Sepn. of fr. IV by VLC on diol modified silica gel (15 μm, 60 mm×35 mm i.d., stepwise with a *n*-hexane–EtOAc gradient) resulted in the isolation of **11** (7 mg).

3.4. 3-Oxo-labda-8(17),13(16),14-triene (*1*)

$[\alpha]_D^{20}$ +34.5 ($CHCl_3$; *c* 2.0); GC–MS (EI) *m*/*z* (rel. int.): 286 $[M]^+$ (12), 271 (21), 133 (37), 119 (41), 107 (54), 93 (100), 81 (58), 79 (71), 67 (46), 55 (50); IR ν_{max}^{KBr}: cm^{-1}: 2910, 1700, 1450, 1375; ^{1}H NMR: 0.83 (3H, *s*, H-20), 1.00 (3H, *s*, H-19), 1.07 (3H, *s*, H-18), 1.50 (1H, *m*, H-1), 1.51 (1H, *m*, H-6), 1.58 (1H, *dd*, *J* = 2.7, 12.8 Hz, H-5), 1.59 (1H, *m*, H-11), 1.68 (1H, *m*, H-11), 1.69 (1H, *m*, H-9), 1.71 (1H, *m*, H-6), 2.00 (1H, *m*, H-1), 2.01 (1H, *m*, H-7), 2.02 (1H, *m*, H-12), 2.34 (1H, *m*, H-2), 2.40 (1H, *ddd*, *J* = 3.2, 3.2, 12.8 Hz, H-7), 2.45 (1H, *m*, H-12), 2.59 (1H, *ddd*, *J* = 6.0, 12.3, 14.8 Hz, H-2), 4.62 (1H, *s*, H-17), 4.91 (1H, *d*, *J* = 1.8 Hz, H-17), 4.94 (1H, *s*, H-16), 4.98 (1H, *s*, H-16), 5.03 (1H, *d*, *J* = 10.8 Hz, H-15), 5.18 (1H, *d*, *J* = 17.6 Hz, H-15), 6.33 (1H, *d*, *J* = 10.8, 17.6 Hz, H-14); ^{13}C NMR: Table 1.

3.5. 3,11-Dioxo-labda-8(17),13(16),14-triene (*2*)

$[\alpha]_D^{20}$ +12.1 ($CHCl_3$; *c* 2.5); GC–MS (EI) *m*/*z* (rel. int.): 300 $[M^+]$ (8), 205 (42), 189 (37), 163 (33), 121 (50), 107 (83), 95 (54), 79 (46), 67 (100), 55 (62); IR ν_{max}^{KBr}: cm^{-1}: 2900, 1690, 1445, 1370; ^{1}H NMR: 0.92 (3H, *s*, H-19), 0.93 (3H, *s*, H-18), 1.16 (3H, *s*, H-20), 1.33 (1H, *m*, H-5), 1.34 (1H, *m*, H-1), 1.51 (1H, *dddd*, *J* = 4.5, 13.0,13.0,13.0 Hz, H-6), 1.58 (1H, *m*, H-6), 1.83 (1H, *ddd*, *J* = 3.0, 6.0, 13.6 Hz, H-1), 1.98 (1H, *ddd*, *J* = 5.3, 13.0, 13.0 Hz, H-7), 2.14 (1H, *ddd*, *J* = 3.0, 3.0, 13.6 Hz, H-2), 2.34 (1H, *ddd*, *J* = 2.2, 4.5, 13.0 Hz, H-7), 2.56 (1H, *ddd*, *J* = 6.0, 13.6, 13.6 Hz, H-2), 3.01 (1H, *s*, H-9), 3.15 (1H, *d*, *J* = 15.4 Hz, H-12), 3.22 (1H, *d*, *J* = 15.4 Hz, H-12), 4.37 (1H, *s*, H-17), 4.80 (1H, *s*, H-17), 4.96 (1H, *s*, H-16), 4.99 (1H, *d*, *J* = 10.6 Hz, H-15), 5.05 (1H, *d*, *J* = 17.5 Hz, H-15), 5.12 (1H, *s*, H-16), 6.28 (1H, *dd*, *J* = 10.6, 17.5 Hz, H-14); ^{13}C NMR: Table 1.

3.6. 3β-Hydroxy-11-oxo-labda-8(17),13(16),14-triene (*3*)

$[\alpha]_D^{20}$ +9.8 ($CHCl_3$; *c* 1.5); GC–MS (EI) *m*/*z* (rel. int.): 302 $[M^+]$ (8), 189 (33), 135 (42), 121 (100), 107 (50), 95 (58), 81 (37), 67 (62), 55 (42); IR ν_{max}^{KBr}: cm^{-1}: 3410, 2920,

1700, 1630, 1440, 1380, 1350, 1240, 1170, 1080, 1020, 920, 890; ^{1}H NMR: 0.75 (3H, *s*, H-19), 0.97 (3H, *s*, H-18), 1.02 (1H, *m*, H-5), 1.04 (3H, *s*, H-20), 1.12 (1H, *ddd*, $J=4.8$, 12.5, 12.5 Hz, H-1), 1.44 (1H, *dddd*, $J=4.5$, 13.0, 13.0, 13.0 Hz, H-6), 1.56 (1H, *m*, H-2), 1.62 (1H, *m*, H-2), 1.71 (1H, *m*, H-6), 1.72 (1H, *m*, H-1), 2.01 (1H, *ddd*, $J=5.3$, 13.0, 13.0 Hz, H-7), 2.40 (1H, *ddd*, $J=2.3$, 4.5, 13.0 Hz, H-7), 3.01 (1H, *s*, H-9), 3.23 (1H, *d*, $J=15.6$ Hz, H-12), 3.25 (1H, *dd*, $J=5.0$, 10.5 Hz, H-3), 3.29 (1H, *d*, $J=15.6$ Hz, H-12), 4.41 (1H, *s*, H-17), 4.82 (1H, *s*, H-17), 5.04 (1H, *s*, H-16), 5.09 (1H, *d*, $J=10.5$ Hz, H-15), 5.14 (1H, *d*, $J=17.5$ Hz, H-15), 5.21 (1H, *s*, H-16), 6.38 (1H, *dd*, $J=10.5$, 17.5 Hz, H-14); ^{13}C NMR: Table 1.

3.7. 3α-Hydroxy-11-oxo-labda-8(17),13(16),14-triene (**4**)

$[\alpha]_D^{20}$ +47.0 ($CHCl_3$; *c* 1.5); GC–MS (EI) *m*/*z* (rel. int.): 302 $[M]^+$ (4), 189 (75), 135 (50), 121 (41), 119 (100), 107 (54), 95 (66), 81 (46), 67 (75). 55 (33); IR ν_{max}^{KBr}: cm^{-1}: 3400, 2910, 1700, 1630, 1590, 1440, 1380, 1050, 980, 890; ^{1}H NMR: 0.82 (3H, *s*, H-19), 0.92 (3H, *s*, H-18), 1.05 (3H, *s*, H-20), 1.39 (1H, *m*, H-1), 1.42 (1H, *m*, H-6), 1.50 (1H, *m*, H-2), 1.57 (1H, *m*, H-5), 1.59 (1H, *m*, H-1), 1.62 (1H, *m*, H-6), 1.92 (1H, *m*, H-2), 2.08 (1H, *ddd*, $J=5.0$, 13.0, 13.0 Hz, H-7), 2.39 (1H, *ddd*, $J=2.2$, 5.0, 13.0 Hz, H-7), 3.14 (1H, *s*, H-9), 3.28 (1H, *d*, $J=16.4$ Hz, H-12), 3.29 (1H, *d*, $J=16.4$ Hz, H-12), 3.42 (1H, *dd*, $J=3.8$, 3.8 Hz, H-3), 4.41 (1H, *s*, H-17), 4.80 (1H, *s*, H-17), 5.02 (1H, *s*, H-16), 5.08 (1H, *d*, $J=11.0$ Hz, H-15), 5.11 (1H, *d*, $J=17.5$ Hz, H-15), 5.20 (1H, *s*, H-16), 6.38 (1H, *dd*, $J=11.0$, 17.5 Hz, H-14); ^{13}C NMR: Table 1.

3.8. 3β-Hydroxy-labda-8(17),13(16),14-triene (**5**)

$[\alpha]_D^{20}$ +12.1 ($CHCl_3$; *c* 1.3); GC–MS (EI) *m*/*z* (rel. int.) 288 $[M]^+$ (2), 135 (75), 133(25), 119 (46), 107 (71), 93 (100), 81 (66), 79 (79), 67 (50), 55 (54); IR ν_{max}^{KBr}: cm^{-1}: 3400, 3050, 2900, 1690, 1630, 1580, 1440, 1370, 1170, 1110, 1070, 1020, 880; ^{1}H NMR: 0.66 (3H, *s*, H-20), 0.74 (3H, *s*, H-19), 0.96 (3H, *s*, H-18), 1.04 (1H, *s*, H-5), 1.09 (1H, *s* H-1), 1.36 (1H, *m*, H-6), 1.51 (1H, *m*, H-11), 1.54 (1H, *m*, H-2), 1.58 (1H, *m*, H-9), 1.64 (1H, *m*, H-11), 1.65 (1H, *m*, H-2), 1.73 (1H, *m*, H-6), 1.75 (1H, *ddd*, $J=3.5$, 3.5, 3.1 Hz, H-1), 1.98 (1H, *m*, H-7), 1.99 (1H, *m*, H-12), 2.34 (1H, *m*, H-12), 2.38 (1H, *ddd*, $J=3.3$, 3.3, 13.1 Hz, H-7), 3.23 (1H, *dd*, $J=4.4$, 11.9 Hz, H-3), 4.54 (1H, *s*, H-17), 4.83 (1H, *s*, H-17), 4.94 (1H, *s*, H-16), 4.97 (1H, *s*, H-16), 5.01 (1H, *d*, $J=10.6$ Hz, H-15), 5.18 (1H, *d*, $J=17.7$ Hz, H-15), 6.33 (1H, *dd*, $J=10.6$, 17.7 Hz, H-14); ^{13}C NMR: Table 1.

3.9. 11-Hydroxy-3-oxo-labda-8(17),13(16),14-triene (**6**)

$[\alpha]_D^{20}$ +8.14 ($CHCl_3$; *c* 1.2); GC–MS (EI) *m*/*z* (rel. int.): 302 $[M^+]$ (4), 149 (37), 133 (42), 121 (54), 109 (58), 107 (66), 91 (75), 81 (71), 69 (95), 55 (100); IR ν_{max}^{KBr}: cm^{-1}: 3480, 2920, 1690, 1630, 1450, 1380, 1090, 890; ^{1}H NMR: 1.03 (3H, *s*, H-19), 1.04 (3H, *s*, H-18), 1.23 (3H, *s*, H-20), 1.47 (1H, *dd*, $J=3.7$, 11.9 Hz, H-5), 1.52 (1H, *m*, H-1), 1.59 (1H, *m*, H-6), 1.65 (1H, *m*, H-6), 1.69 (1H, *s*, H-9), 2.00 (1H, *ddd*, $J=5.6$, 12.6, 12.6 Hz, H-7), 2.02 (1H, *m*, H-12), 2.10 (1H, *ddd*, $J=3.2$, 6.2, 13.0 Hz, H-1), 2.32 (1H, *m*, H-2), 2.38 (1H, *m*, H-7), 2.72 (1H, *m*, H-2), 2.73 (1H, *m*, H-12), 4.21 (1H, *ddd*, $J=1.8$, 4.6, 8.8 Hz, H-11), 5.02 (2H, *brs*, H-17 and H-16), 5.08 (1H, *d*, $J=10.5$ Hz, H-15), 5.11 (1H, *dd*, $J=0.6$, 2.1 Hz, H-16), 5.19 (1H, *d*, $J=17.4$ Hz, H-15), 5.27 (1H, *d*, $J=2.1$ Hz, H-17), 6.34 (1H, *dd*, $J=10.5$, 17.4 Hz, H-14); ^{13}C NMR: Table 1.

3.10. Jamesoniellide K (**9**)

$[\alpha]_D^{20}$ −15.4 ($CHCl_3$; *c* 0.9); EIMS *m*/*z* (rel. int.): 390 $[M]^+$ (15), 252 (44), 207 (75), 166 (48), 149 (46), 123 (44), 105 (35), 91 (51), 77 (38), 44 (100); IR ν_{max}^{KBr}: cm^{-1}: 3450, 2900, 2880, 1740, 1630, 1300, 1250, 1190, 1000, 860, 750; ^{1}H NMR: 1.24 (3H, *s*, H-19), 1.78 (1H, *m*, H-1), 2.00 (1H, *m*, H-1), 2.30 (3H, *s*, H-20), 2.35 (1H, *ddd*, $J=1.8$, 3.7, 7.3 Hz, H-2), 2.43 (1H, *m*, H-2), 2.73 (2H, *brs*, H-7), 2.84 (1H, *dd*, $J=4.5$, 16.5 Hz, H-11), 3.21 (1H, *dd*, $J=9.1$, 16.5 Hz, H-11), 4.14 (1H, *dd*, $J=2.3$, 4.5 Hz, H-10), 4.64 (1H, *dd*, $J=7.3$, 7.3, H-6), 5.27 (1H, *dd*, $J=4.5$, 9.1 Hz, H-12), 6.12 (1H, *brs*, H-15), 6.93 (1H, *dd*, $J=3.7$, 3.7 Hz, H-3), 7.19 (1H, *brs*, H-14); ^{13}C NMR: Table 1.

3.11. Jamesoniellide L (**10**)

$[\alpha]_D^{20}$ −11.8 ($CHCl_3$; *c* 0.25); EIMS *m*/*z* (rel. int.): 390 $[M]^+$ (2), 207 (93), 169 (84), 166 (64), 149 (90), 137 (69), 123 (46), 119 (66), 105 (60), 91 (100); IR ν_{max}^{KBr}: cm^{-1}: 3400, 2910, 2890, 1750, 1630, 1310, 1260, 1190, 1010, 860, 750; ^{1}H NMR: 1.24 (3H, *s*, H-19), 1.78 (1H, *m*, H-1), 2.00 (1H, *m*, H-1), 2.30 (3H, *s*, H-20), 2.35 (1H, *ddd*, $J=1.8$, 3.7, 7.3 Hz, H-2), 2.43 (1H, *m*, H-2), 2.73 (2H, *brs*, H-7), 2.84 (1H, *dd*, $J=4.5$, 16.5 Hz, H-11), 3.21 (1H, *dd*, $J=9.1$, 16.5 Hz, H-11), 4.14 (1H, *dd*, $J=2.3$, 4.5 Hz, H-10), 4.64 (1H, *dd*, $J=7.3$, 7.3, H-6), 5.38 (1H, *brs*, H-12), 6.09 (1H, *s*, H-14), 6.20 (1H, *brs*, H-16), 6.92 (1H, *dd*, $J=3.8$, 3.8 Hz, H-3); ^{13}C NMR Table 1.

3.12. 6,6′,10,10′,12,12′-Hexachloroisoperrottetin A (**11**)

$[\alpha]_D^{20}$ +0.0 ($CHCl_3$; *c* 0.2); DCIMS *m*/*z* (rel. int.) 630 $[M]^+$, 630:632:634:636:648:640 (65:100:70:35:6:1), 412 $[M\text{-}210]^+$; IR ν_{max}^{KBr}: cm^{-1}: 3450, 2900, 2850, 1710, 1560, 1460, 1410, 1230, 1170, 790; UV λ_{max} nm 286, λ_{min} 261; ^{1}H NMR: 2.83 (4H, *m*, H-8 and H-8′), 2.98 (4H, *m*, H-7 and H-7′), 6.66 (2H, *d*, $J=8.2$ Hz, H-14 and H-14′), 6.83 (2H, *d*, $J=1.9$ Hz, H-3 and H-3′), 7.15 (2H, *d*, $J=8.2$ Hz, H-13 and H-13′), 7.20 (2H, *d*, $J=1.9$ Hz, H-5 and

H-5′); ^{13}C NMR: 34.7 (*t*, C-8 and C-8′), 35.4 (*t*, C-7 and C-7′), 118.7 (*s*, C-12 and C-12′), 121.0 (*s*, C-10 and C-10′), 122.0 (*d*, C-14 and C-14′), 125.4 (*s*, C-2 and C-2′), 127.4 (*d*, C-13 and C-13′), 129.0 (*d*, C-5 and C-5′), 130.1 (*d*, C-3 and C-3′), 130.2 (*s*, C-6 and C-6′), 134.3 (*s*, C-4 and C-4′), 138.7 (*s*, C-9 and C-9′), 147.9 (*s*, C-11 and C-11′), 146.9 (*s,* C-1 and C-1′).

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