Hodgsonox, a New Class of Sesquiterpene from the Liverwort *Lepidolaena hodgsoniae*. Isolation Directed by Insecticidal Activity

Gary D. Ainge, Philippa J. Gerard,† Simon F. R. Hinkley, Stephen D. Lorimer, and Rex T. Weavers*

Plant Extracts Research Unit, New Zealand Institute for Crop and Food Research, Department of Chemistry, University of Otago, Dunedin, New Zealand, and AgResearch, Ruakura Agricultural Research Centre, Hamilton, New Zealand

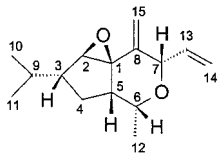
rweavers@alkali.otago.ac.nz

Received December 19, 2000

Hodgsonox (**1**), a new insecticidal sesquiterpene, has been isolated from the New Zealand liverwort *Lepidolaena hodgsoniae*. The structure was elucidated on the basis of 2D NMR analysis of **1** and a synthetic epoxide derivative (**2**). Hodgsonox represents a new class of sesquiterpene with a cyclopenta[5,1-*c*]pyran ring system fused to an oxirane ring. The combination of a mono- and a 1,1 disubstituted double bond flanking the oxygenated carbon of a the pyran ring is a unique structural feature. Hodgsonox is toxic to larvae of the blowfly *Lucilia cuprina*.

Introduction

As part of our current research program, we have been investigating New Zealand native flora for new biologically active compounds. New Zealand liverworts have proved to be a particularly rich source of new natural products,[1−3] and we have recently reported studies on two other members of the genus *Lepidolaena* (family Lepidolaenaceae).[4,5] In the present paper, we report the results of a bioactivity-directed isolation of a new insecticidal sesquiterpene that we have named hodgsonox (**1**) from *L. hodgsoniae* Grolle. Hodgsonox has a novel sesquiterpene ring system and includes a unique doubly allyllic ether function.



1

Results and Discussion

Samples of *L. hodgsoniae* were first collected from the New Zealand sub-Antarctic Campbell Island[6] but were subsequently sourced from mixed podocarp forest on the West Coast of the South Island of New Zealand. An ethanolic extract was submitted to a range of agrochemical and pharmaceutical screens. Significant larval growth inhibition was noted against the Australian green blowfly, *Lucilia cuprina* Weidemann (Diptera: Calliphoridae), and this assay was used to direct the isolation of the active component. A bulk extract was subjected to reversed-phase flash chromatography, using a $H_2O-CH_3CN-CHCl_3$ gradient. Biological activity was observed in each of the three fractions that were eluted with 75%, 90%, and 100% CH_3CN/H_2O. The first of these fractions to elute induced inhibition of larval development, and the next two produced high mortality. The latter two fractions were combined and chromatographed over silica using a hexane−$CHCl_3$−CH_3CN gradient. The most active fraction was found to contain a single compound, hodgsonox (**1**), recovered in 0.02% of the dry weight of liverwort.

High-resolution MS (EI) of hodgsonox revealed the parent ion at 234.1619 Da which corresponds to the molecular formula $C_{15}H_{22}O_2$ (234.1619). This was consistent with the 15 discrete signals observed in the ^{13}C NMR spectrum coupled with the results of a DEPT experiment. The IR spectrum showed neither hydroxyl nor carbonyl stretching bands, and signals in the ^{13}C NMR spectrum (δ_C 70.35, 71.87, 73.82, and 81.08) suggested the two oxygen atoms were incorporated in ether linkages. The compound was determined to be tricyclic as the ^{13}C NMR spectrum also revealed the presence of two double bonds. The ^1H NMR spectrum contained a one-proton singlet at δ 3.14, consistent with an epoxide, and demonstrated the double bonds to be monosubstituted (δ_H 5.11 ddd, 5.30 ddd, 5.80 ddd) and 1,1-disubstituted (δ_H 4.87 brs, 5.12 brs).

The ^1H NMR spectrum was complicated by overlaps of two peaks at δ 4.87 and peaks centered at δ 5.11 and 5.12. No significant signal dispersion was obtained by recording spectra in a variety of solvents (benzene, pyridine, acetone, DMSO, methanol). Nonetheless, more detailed NMR analysis (HMQC, HMBC, COSY, and single-frequency decoupling), making use of unambiguous data, enabled the derivation of a structure for hodgsonox. NMR results are summarized in Table 1. The COSY

† Ruakura Agricultural Research Centre.

(1) Lorimer, S. D.; Perry, N. B.; Burgess, E. J.; Foster, L. M. *J. Nat. Prod.* **1997**, *60*, 421−424.
(2) Baek, S.-H.; Perry, N. B.; Weavers, R. T.; Tangney, R. S. *J. Nat. Prod.* **1998**, *61*, 126−129.
(3) Lorimer, S. D.; Perry, N. B. *Planta Med.* **1994**, *60*, 386−387.
(4) Perry, N. B.; Burgess, E. J.; Tangney, R. S. *Tetrahedron Lett.* **1996**, *37*, 9387−9390.
(5) Perry, N. B.; Burgess, E. J.; Baek, S.-H.; Weavers, R. T.; Geis, W.; Mauger, A. B. *Phytochemistry* **1999**, *50*, 423−433.
(6) Lorimer, S. D.; Barns, G.; Evans, A. C.; Foster, L. M.; May, B. C. H.; Perry, N. B.; Tangney, R. S. *Phytomedicine* **1996**, *2*, 327−333.

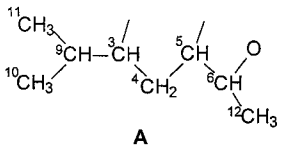
10.1021/jo0017685 CCC: $20.00
Published on Web 03/23/2001

Table 1. NMR Data for Hodgsonox in $CDCl_3$

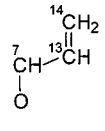
position (H)	δ_C	δ_H (m, Hz)[a]	COSY[b]	HMBC[b,c]
1	70.35 s			
2	73.82 d	3.14 s		3, 4
3	48.17 d	1.77 m	4a, 4b, 9	1, 2, 4, 9, 10, 11
4a	33.48 t	1.83 ddd, 7, 7, 12	3, 4b, 5	1, 2, 3, 5
4b		2.00 ddd, 9, 9, 12	3, 4a, 5	3, 5, 6, 9
5	45.83 d	2.12 ddd, 4, 7, 9	4a, 4b, 6	1, 12
6	71.87 d	3.92 dq, 4, 7	5, 12	4, 7, 12
7	81.08 d	4.87 ddd, 1.5, 1.5, 6	*13*	*1, 13, 14, 15*
8	143.55 s			
9	29.96 d	1.65 m	3, 10, 11	2, 3, 4, 10, 11
10	20.56 q	0.93 d 7	9	3, 9, 11
11	21.08 q	1.00 d 7	9	3, 9, 10
12	17.65 q	1.15 d 7	6	5, 6
13	138.00 d	5.80 ddd, 6, 10, 17	*7*, *14a*, 14b	7
14a	115.39 t	5.11 ddd, 1, 1.5, 10	*13*	*7*
14b		5.30 ddd, 1.5, 1.5, 17	13	
15a	108.03 t	4.87 br s		*1, 7*
15b		5.12 br s		*1, 7, 8*

[a] Recorded at 500 MHz. [b] Numbers in *italics* are tentative as a result of ^{1}H peak overlaps. [c] Correlation from proton signal to numbered carbon signal.

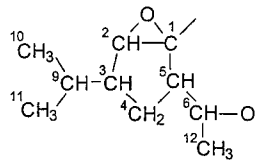
experiment, combined with analysis of coupling constants and single-frequency decouplings, allowed the construction of substructures **(A)** and (**B**). An HMBC correlation from H-9 (δ_H 1.65) to the carbon resonance of an oxygenated methine (C-2, δ_C 73.82) established a connection between C-2 and C-3. Furthermore, correlations to an unprotonated carbon signal at δ 70.35 (C-1) from H-3 (δ_H 1.77), one of the H-4 signals (δ_H 1.83), and the H-5 peak (δ_C 2.12) allowed completion of a five-membered ring. The H-2 chemical shift (δ_H 3.14) suggested that C-1 and C-2 were involved in an oxirane ring to give substructure (**C**). Amalgamation of the **B** and **C** subunits via a C-6 to C-7 ether linkage was enabled by a correlation from the H-6 resonance (δ_H 3.92) to the C-7 signal (δ_C 81.08) in the HMBC spectrum. This left the 1,1,-disubstituted double bond to be inserted between C-1 and C-7 to complete the gross structure of hodgsonox as in **1**. However, the fact that the H-2 epoxidic proton signal (δ_H 3.14) appeared as a very sharp singlet seemed a little difficult to reconcile.



A



B



C

To verify this proposed structure, the diepoxide (**2**) was prepared by treatment of **1** with *m*-CPBA. One-proton doublets in the ^{1}H NMR spectrum at δ_H 2.59 and 2.85 were consistent with epoxidation of the more electron-rich disubstituted double bond. It was pleasing to find

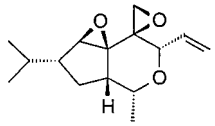
Table 2. NMR Data for Diepoxide 2 in $CDCl_3$

position (H)	δ_C	δ_H (m, Hz)[a]	COSY	HMBC[b]
1	67.59 s			
2	69.15 d	3.27 s		3, 4
3	48.27 d	1.79 ddd, 7, 7, 9	4a, 9	1, 2, 9, 10
4a	33.17 t	1.89 ddd, 7, 8, 12	4b, 5	3, 5, 9
4b		2.05 ddd, 9, 9, 12	4a, 5	1, 3
5	44.46 d	2.29 ddd, 4, 8, 9	4a, 4b, 6	1, 4
6	70.81 d	4.38 dq, 4, 7	5, 12	7
7	82.80 d	4.12 ddd, 1, 1, 7	13, 14a, 14b, 15a	1, 8, 13, 14
8	59.77 s			
9	30.11 d	1.67 m, $W_{h/2}$ 22	3, 10, 11	3, 11
10	20.89 q	0.96 d, 7	9	3, 9
11	21.36 q	1.03 d, 7	9	3, 9
12	17.71 q	1.21 d, 7	6	5, 6
13	134.96 d	5.82 ddd, 7, 10, 17	7, 14a, 14b	7
14a	117.96 t	5.21 ddd, 1, 1.5, 11	7, 13	7
14b		5.35 ddd, 1.5, 1.5, 17	7, 13	7, 13
15a	45.38 t	2.59 d 4.5	7, 15b	1, 7, 8
15b		2.85 d 4.5	15a	1, 7, 8

[a] Recorded at 300 MHz. [b] Correlation from proton signal to numbered carbon signal.

from an HMQC experiment that there was no signal overlap in the ^{1}H NMR spectrum (Table 2).

As expected, the high-resolution MS (EI) of **2** revealed the parent ion at 250.1571 Da ($C_{15}H_{22}O_3$ requires 250.1569), and the IR spectrum indicated monosubstituted alkene functionality (ν_{max} 1644, 1061 cm^{-1}; CH=CH_2). Again, the COSY spectrum (Table 2) established



2

the connectivity between the protonated carbons of substructures **A** and **B**. As in the parent alkene, the epoxidic proton (H-2) generated a very sharp singlet in the ^{1}H NMR spectrum (δ_H 3.27). Despite this lack of significant coupling between H-2 and H-3, the fact that these centers were adjacent was again demonstrated by HMBC correlations where H-2 mapped on to both C-3 (δ_C 48.27) and C-4 (δ_C 33.17), and H-3 (δ_H 1.79) on to both C-2 (δ_C 69.15) and C-1 (δ_C 67.59). A correlation between one of the C-4 protons (δ_H 2.05) and C-1 allowed completion of the five-membered ring. Correlations involving both proton signals of the newly introduced exocyclic epoxide function (δ_H 2.59, 2.85) supported the proposed positioning of this function between C-1 (δ_C 67.59) and C-7 (δ_C 82.80). This section of the molecule had been constructed by default in the structural analysis conducted on **1**. Further support for the remainder of the six-membered ring structure was obtained from HMBC correlations between H-7 (δ_H 4.12) and both C-1 and C-8 (δ_C 59.77), and also between H-6 (δ_H 4.38) and C-7 (δ_C 82.80). The full set of HMBC correlations (Table 2) led

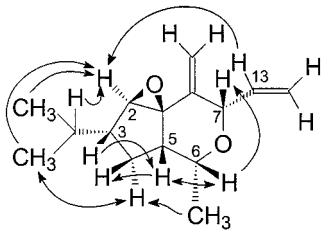


Figure 1. Hodgsonox (**1**) showing key NOE interactions.

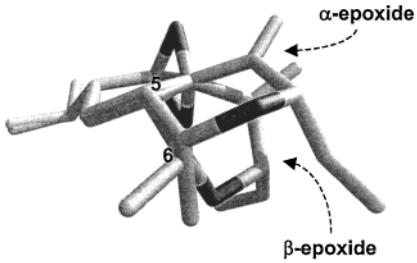


Figure 2. Overlay of predicted lowest energy conformations of α- and *β*-epoxide forms of hodgsonox (**1**).

to an unambiguous set of connectivities verifying structure **2** in accordance with the proposed structure for hodgsonox **1**.

The relative stereochemistry was determined primarily by NOE difference experiments conducted on **1**. The NOE data indicated that H-3, H-5, H-6, and H-7 all lie on one face of the molecule (as depicted in Figure 1). This established all of the relative stereochemical features apart from the orientation of the epoxide ring. The fact that H-2 resonates as a very sharp singlet in the ^{1}H NMR spectrum suggested that it would be useful to predict the coupling constant between H-2 and H-3 by molecular modeling. Molecular modeling (MM2 force field[7]) conducted on **1** revealed a number of low energy conformations that varied only by rotation of the isopropyl and vinyl groupings. Calculation based on the Boltzmann weighted average of these conformations gave a coupling constant, $J_{2,3} = 0.7$ Hz. Similar modeling of the α-isomer gave a coupling constant, $J_{2,3} = 1.5$ Hz. The calculations also indicated that the preferred conformations of the six-membered ring are quite different for the α- and *β*-epoxides. The calculated minimum energy conformations are shown overlaid in Figure 2. Again, the observed H-5/H-6 coupling constant ($J_{5,6} = 4.0$ Hz) is closer to that predicted for the *β*-epoxide ($J_{5,6} = 3.7$ Hz) than for the α-epoxide ($J_{5,6} = 5.3$ Hz). Further evidence for the proposed *β*-epoxide stereochemistry was derived from NOE experiments where a small enhancement of the H-2 singlet was observed upon irradiation of the H-13 proton. Modeling showed that this enhancement is only compatible with the *β*-epoxide stereochemistry.

NOE experiments and molecular modeling completed on the diepoxide **2** were consistent with the stereochemistry assigned to the parent diene (Figure 3). Three factors contributed to the assignment of the 8,15-epoxide oxygen to the *β* face of the molecule. Molecular modeling suggests that the overall shape of the ring system of **1** is bowed, favoring *β*-face attack by the peracid. Second, an NOE was observed from H-14 to H-2. Molecular modeling indicates that this is only possible with the relative

(7) Allinger, N. L. *J. Am. Chem. Soc.* **1977**, *99*, 8127−8134.

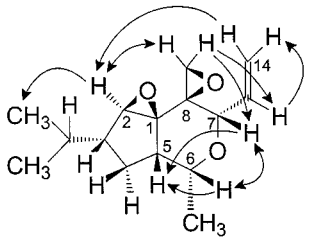
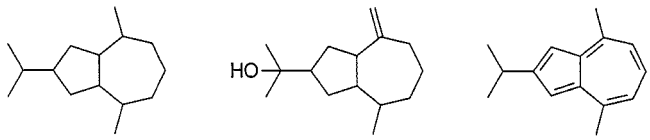


Figure 3. Diepoxide **2** showing key NOE interactions.

stereochemistry depicted. Further evidence comes from analysis of the predicted and observed ^{1}H NMR coupling data. As in the parent diene **1**, the conformation of the six membered ring in **2** is dependent on the relative stereochemistry at C-1 and C-2 and additionally on that at C-8. NOE experiments leave no question that H5, H6, and H7 must lie on the same face of the molecule, and the observed H5 to H6 coupling constant of 4.0 Hz is consistent with that predicted for the 8*β*,15*β*-epoxide ($J_{5,6} = 3.7$ Hz) rather then the α-epoxide ($J_{5,6} = 6.1$ Hz). This argument leads to the full relative stereochemical assignment of the diepoxide **2**, but the absolute stereochemistry remains undetermined.

In conclusion, we have isolated a new insecticidal sesquiterpene, hodgsonox (**1**), from the New Zealand liverwort *L. hodgsoniae*. This structure represents a new class of sesquiterpene. It is inviting to speculate that the biosynthesis may involve bond cleavage of the carbon skeleton (**3**), a regular isoprenoid structure. However, it is doubtful whether there are any representatives of this carbon framework in nature. A compound named bicyclovetivenol was reported as having structure (**4**)[8] but this was prior to the use of NMR and the compound has not been isolated pure.[9] For some years it was believed that α and *β*-vetivone also belonged to this structural family,[10] but this has since been disproved.[11] There are reports of the presence of azulene derivative (**5**) in steam distillates of foliage,[11] but given the propensity of many sesquiterpenes to rearrange to an azulene skeleton, it is quite probable that **5** is not a genuine natural product. A CAS search of a monosubstituted double bond and a 1,1-disubstituted double bond in a doubly allylic ether arrangement also reveals that this subunit is a novel one.



3 **4** **5**

Hodgsonox exhibits activity against the larvae of the Australian green blowfly *L. cuprina*. A serial dilution study provided an LC_{50} of 0.27 mg/mL (in the assay serum). In the same assay, diazinon, a currently used insecticide, gave an LC_{50} of 0.0016 mg/mL. Thus, the activity of hodgsonox is not comparable with existing

(8) Chiurdoglu, G.; Delsemme, A. H. *Bull. Soc. Chim. Belg.* **1961**, *70*, 5−25.

(9) Glasby, J. S. *Encyclopaedia of the Terpenes*; Wiley: Chichester, 1982.

(10) Romanuk, M.; Herout, V. *Collect. Czech. Chem. Commun.* **1960**, *25*, 2540−2552.

(11) *Dictionary of Natural Products*; Buckingham, J., Ed.; Chapman & Hall: London, 1992.

agents, but it is hoped that our ongoing study of derivatives and analogues will produce compounds with development potential.

Experimental Section

General Methods. GC analysis was completed on a 10 m DB-1 silica column; oven 50−250 °C at 10° min^{-1}/DET 350/INJ 260 H_2 carrier gas at 10 PSI with a linear flow velocity of 55 cm s^{-1} and split ratio of 100:1. Results are reported as a retention index (RI).[12] NMR measurements were carried out at 300 or 500 MHz for ^1H and 75 MHz for ^{13}C and were performed in $CDCl_3$ at 25 °C; chemical shifts are given in ppm on the δ scale referenced to the solvent peaks C*H*Cl_3 at 7.25 and *C*DCl_3 at 77.00. IR spectra were recorded using an FT-IR spectrometer. Optical rotations were measured as $CHCl_3$ solutions using a digital polarimeter. Silica gel column chromatography was performed on Merck Kieselgel 9385. Octadecyl-functionalized silica gel (C18) was used for reversed-phase (RP) flash chromatography. Radial chromatography was carried out using a Harrison Research 7924T Chromatotron with plates coated with a 1 mm layer of Merck (Art 7749) silica gel 60 PF_{254} with $CaSO_4 \cdot {}^1/_2H_2O$ applied as a slurry and dried. All chromatographic solvents were distilled prior to use.

Molecular Modeling. The method is described in ref 13. Coupling constant data were calculated on the Boltzmann weighted average of the conformations discovered by the Monte Carlo torsion search procedure.

Collection. *L. hodgsoniae* was collected from Campbell Island (52° 53′ south, 169° 10′ east) or the Cascade area of the South Island, New Zealand (44 06′ south, 168 31′ east). Vouchers of these collections are held in the Otago University Herbarium; OTA 46706 and 6810.

Biological Assay. The *L. cuprina* assay method has been published elsewhere.[14] The activity is represented as the percentage of live 2nd instars (normally developed larvae) and percentage of dead larvae (mortality) present at the time of evaluation. For solvent controls this is normally 100% and 0% respectively.

Bioactivity-Directed Isolation of (1). Frozen plant material (127 g, from collection OTA 46706) was extracted by blending with EtOH (1 × 300 mL, then 2 × 200 mL) to give a crude extract (2.4 g, 29% live second instar, 0% mortality at 8 mg/mL). This extract (2.2 g) was subjected to reversed-phase flash chromatography over C_{18} (adsorbed onto 4.4 g C_{18}, loaded on to a 10 g C_{18} column), eluting with an $H_2O-CH_3CN-CHCl_3$ gradient over seven steps. Activity was spread over three fractions that eluted with 1:3 H_2O/CH_3CN (56% live second instar, 11% mortality at 8 mg/mL), 1:9 H_2O/CH_3CN (0% live second instar, 100% mortality at 8 mg/mL) and CH_3CN (0% live second instar, 99% mortality at 8 mg/mL). The latter two fractions were combined (103 mg), and chromatographed over silica eluting with a hexane-$CHCl_3-CH_3CN$ gradient. Fractions from this column were collected on the basis of TLC. One fraction that eluted with hexane/$CHCl_3$ (1:3) contained pure **1** (24 mg; 0% live second instar, 100% mortality at 4 mg/mL).

Hodgsonox ([2ξ-(1aα,2α,3aβ,4α,6α,7a*R)]-6-Ethenyl-2-isopropyl-4-methyl-7-methylene-1a,2,3,3a,6,7-hexahydro-4*H*-oxireno[1,2]cyclopenta[5,1-*c*]pyran) (1).** Silica gel TLC R_f 0.56 ($CHCl_3$, vanillin, purple); OR $[\alpha]^{25}$ +78 (589 nm), $[\alpha]^{26}$ +81 (577 nm), $[\alpha]^{27}$ +91 (546 nm), $[\alpha]^{27}$ +153 (435 nm), $[\alpha]^{27}$ +191 (405 nm) (*c* 0.92, $CHCl_3$); IR ($CDCl_3$ solution) ν_{max} 2962, 1632, 1460, 1379, 1239, 1060 cm^{-1}; RI = 1499; HRMS [intensity] 234.1619 [3] (M^+, $C_{15}H_{22}O_2$ requires 234.1619), 219 [5] ($M^+ - CH_3$), 206 [3] ($M^+ - CH_3 - H_2O$), 191 [20] ($M^+ - {}^i$Pr), 175 [32], 147 [95], 131 [22], 129 [21], 121 [30], 119 [36], 105 [40], 91 [94], 81 [100], 78 [69], 76 [41], 69 [29], 55 [51]; NMR Table 1.

Optimized Isolation. The air-dried foliage (51 g) was extracted by homogenization in a Waring blender with $CHCl_3$ (600 mL, 2 × 200 mL) and EtOH (200 mL). Solvent removal (<35 °C) yielded a green gum (2.9 g). Silica gel chromatography (40 × 125 mm, 80 g) eluting with $CHCl_3$ gave a bright yellow oil (458 mg). Further silica gel column chromatography (25 × 100 mm, 40 g) eluting with hexane then (1:2) $CHCl_3$/hexane, (1:1) $CHCl_3$/hexane, and (4:1) $CHCl_3$/hexane gave hodgsonox (**1**) as a clear oil (180 mg, 3.5 mg/g dried plant). The compound decomposes when stored neat at −4 °C, but this decomposition may be prevented by storage in $CHCl_3$ or EtOH at −4 °C.

Epoxidation of Hodgsonox. Hodgsonox (**1**) (20 mg, 70% pure, 6.0 mmol) was dissolved in dry CH_2Cl_2 (2 mL) and the mixture stirred at −15 °C in a screw top vial. A solution of *m*-CPBA (50 mg, 29 mmol) in CH_2Cl_2 (1 mL) was added dropwise with vigorous stirring. The solution was allowed to warm to room temperature and stirred for a total of 4.5 h. The reaction mixture was then treated with $NaHCO_3$ solution (aq, 10% w/v, 5 mL) and extracted with CH_2Cl_2 (3 mL). The aqueous phase was extracted with a further portion of CH_2Cl_2 (3 mL), and the organic phases were combined, dried ($MgSO_4$), and evaporated to give a yellow oil (46 mg). Purification on a silica column (13 × 240 mm, $CHCl_3$, 25 g) followed by radial chromatography (1 mm silica plate, hexane to 2:5 EtOAc/hexane) yielded [2ξ-(1aα,2α,3aβ,4α,6α,7a*R**)]-6-ethenyl-2-isopropyl-4-methyl-7-oxaspiro-1a,2,3,3a,6,7-hexahydro-4H-oxireno[1,2]cyclopenta[5,1-*c*]pyran (**2**) (7.7 mg, 3 mmol) and an unidentified product (2.4 mg): silica gel TLC R_f 0.57 (40% EtOAc/hexane, vanillin, black); 0.38 ($CHCl_3$); OR $[\alpha]^{25}$ +65 (589 nm), $[\alpha]^{25}$ +64 (577 nm), $[\alpha]^{25}$ +75 (546 nm), $[\alpha]^{25}$ +125 (435 nm), $[\alpha]^{25}$ +151 (405 nm), (*c* 0.57, $CHCl_3$); IR (Film) ν_{max} 2960, 1644, 1451, 1380, 1265, 1167, 1062, 936, 869, 812, 759, 692 cm^{-1}; HRMS 250.1571 [3] (M^+ $C_{15}H_{22}O_3$ requires 250.1569), 235 [8] ($M^+ - CH_3$), 232 [4] ($M^+ - H_2O$), 207 [62] ($M^+ - {}^i$Pr), 189 [20] ($M^+ - {}^i$Pr $- H_2O$), 163 [85],135 [89], 91 [85], 79 [100]; NMR Table 2.

Acknowledgment. We thank Ray Tangney for bryophyte collection and identification, Mervyn Thomas for NMR assistance, Rob Smith for the use of an inverse detection probe, George Slim and Industrial Research Ltd. for 500 MHz NMR, Nigel Perry and Anna Barlow for helpful discussions, and Nerida Brennan, Elaine Burgess, and Lysa Foster for collection and voucher preparation. We also thank the Department of Conservation for permission to collect from Campbell Island.

Supporting Information Available: Spectra (MS, ^1H, and ^{13}C) of **1** and **2**. This material is available free of charge via the Internet at http://pubs.acs.org.

JO0017685

(12) Adams, R. P. *Identification of Essential Oil Components by Gas Chromatography/Mass Spectroscopy*; Allured Publishing Corp.: Carol Stream, IL, 1995.

(13) Hinkley, S. F. R.; Perry, N. B.; Weavers, R. T. *Phytochemistry* **1994**, *35*, 1489−1494.

(14) Gerard, P. J.; Ruf, L. D.; Lorimer, S. D.; Heath, A. G. C. *N. Z. J. Agric. Res.* **1997**, *40*, 261−267.