



A 9 $\alpha$ -configuration for the 2-oxopropyl group of **1** was established by NOE experiments. Irradiation at  $\delta$  3.23 (H-21b proton) caused NOE enhancements only in its geminal (H-21a) and Me-23 proton signals, whereas only the signals of H-1 $\beta$ , H-2 $\beta$ , and Me-19 ( $\delta$  1.78, 1.64, and 1.22, respectively) were enhanced when Me-20 ( $\delta$  0.93) was irradiated. These results indicated that the Me-20 and 2-oxopropyl groups are on opposite sides of the plane of the molecule. The absolute configuration of **1** could not be determined. However, on biogenetic grounds we suppose that it belongs to the *normal* series, like coleon U-quinone (**4**)<sup>12</sup> and other abietane diterpenoids found in *Plectranthus* species.<sup>1–4,10–13</sup>

Since acetone was used for the extraction of the plant material, and structure **1** could be considered as a Michael adduct arising from a molecule of acetone and coleon U-quinone (**4**), **1** could be an artifact. This hypothesis was reinforced by the fact that the C-9 carbon of **4** ( $\delta$  154.9)<sup>12</sup> is the most deshielded of its olefinic carbons and consequently the choice site for an attack of a nucleophilic carbon of acetone. The 9 $\alpha$ -configuration of the 2-oxopropyl group in **1** further supports artifact formation, since the addition of acetone to form **1** must occur from the less hindered  $\alpha$  side of **4**. To determine if **1** is an artifact, another sample of the aerial parts of *P. grandidentatus* (with the same origin that the plant material used for the initial extraction) was extracted using CHCl<sub>3</sub> without acetone as solvent. Subsequent isolation procedures leading to **1** were carried out in the absence of acetone (see Experimental Section), and **1** was ultimately identified among the constituents of the extract. The appearance of **1** in the acetone-free extract provides evidence to support **1** as a natural compound in *P. grandidentatus*.<sup>15</sup>

Trihomobietane diterpenoids are rare as natural products,<sup>1–3</sup> and only a few examples have been reported.<sup>16–22</sup> Some of these substances, such as danshenols A and B found in *Salvia miltiorhiza* Bunge<sup>18</sup> and *S. glutinosa* L.<sup>19,20</sup> (Labiatae), possess a 2-oxopropyl side chain attached to the C-11 position of a 19,20-dinor- or 20-nor-abietane hydrocarbon skeleton, respectively, and they have shown to be substances of natural origin.<sup>18</sup>

To investigate the plausible Michael-type addition of acetone to abietane quinone derivatives, we investigated this reaction with two diterpenoid benzoquinones that were available from previous studies.<sup>9,23</sup> Treatment of the *p*-benzoquinone 7 $\alpha$ -acetoxyroyleanone<sup>23–26</sup> (**5**) with acetone under strong basic conditions (see Experimental Section) did not produce Michael adducts, whereas identical treatment of the *o*-benzoquinone cryptotanshinone<sup>8,9</sup> (**3**, C<sub>19</sub>H<sub>20</sub>O<sub>3</sub>) gave a compound (**2**) whose molecular formula (C<sub>22</sub>H<sub>26</sub>O<sub>4</sub>) indicated that an addition of acetone occurred. The structure of **2** was established as follows.

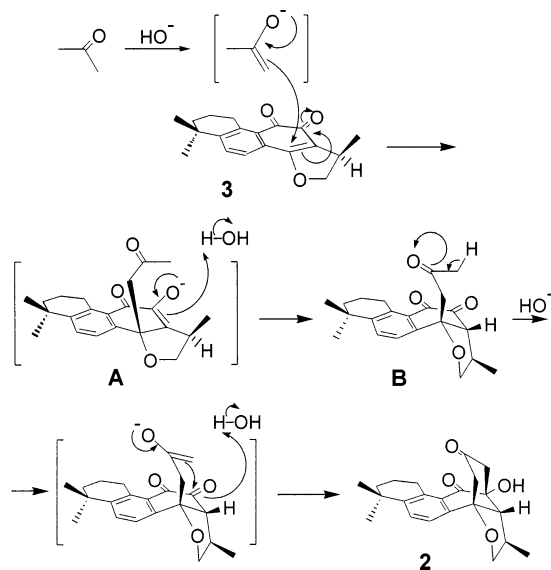
The UV spectrum of **2** showed characteristic absorptions for a substituted acetophenone chromophore<sup>27</sup> [ $\lambda_{\max}$  (log  $\epsilon$ ) 215 (4.43), 258 (4.07), 308 (3.51) nm], and its IR spectrum indicated the presence of hydroxyl (3424 cm<sup>–1</sup>), saturated ketone (1721 cm<sup>–1</sup>), and aryl ketone (3101, 1677, 1590 cm<sup>–1</sup>) groups. The <sup>1</sup>H and <sup>13</sup>C NMR spectra of **2** drastically differed from those of cryptotanshinone<sup>28,29</sup> (**3**), although both compounds showed identical signals and similar chemical shifts for H<sub>2</sub>-1–H<sub>2</sub>-3, H<sub>2</sub>-16 methylene, H-6, H-15 methine, and Me-17–Me-19 methyl groups, and for C-1–C-11 and C-15–C-19. The most significant differences between the <sup>1</sup>H and <sup>13</sup>C NMR spectra of **2** and **3** were consistent with the presence in the former of an additional 2-oxopropan-1,3-diyl part [ $\delta_{\text{H}}$  2.77 and 2.53 dd,  $J_{\text{gem}}$  = 17.0 Hz,  $J_{\text{long range}}$  = 1.5 Hz, H<sub>2</sub>-21, and  $\delta$  2.92 and 2.86 dd,  $J_{\text{gem}}$  = 14.5 Hz,  $J_{\text{long range}}$  = 1.5 Hz, H<sub>2</sub>-23;  $\delta_{\text{C}}$  52.6 (CH<sub>2</sub>, C-21),

204.5 (C, C-22), and 54.8 (CH<sub>2</sub>, C-23)] attached to two different quaternary carbons. In addition, C-12, C-13, and C-14 are transformed from three aromatic quaternary carbons in **3**<sup>28,29</sup> to two alkyl quaternary and a tertiary carbon in **2** [ $\delta$  76.1 (C, C-12), 61.6 (CH, C-13), and 82.3 (C, C-14)]. The HMBC spectrum of **2** showed two- and three-bond connectivities between both H<sub>2</sub>-21 methylene and C-11–C-13, C-22, and C-23. On the other hand, C-8 ( $\delta$  145.0), C-13, C-14, C-21, and C-22 were connected with H<sub>2</sub>-23. Moreover, the methine carbon at  $\delta$  61.6 (C-13) showed HMBC cross-peaks with HO-12, H-16a, and Me-17, and the sp<sup>3</sup> quaternary C-14 ( $\delta$  82.3) was connected with H-7, H-13, and H<sub>2</sub>-16. In addition, the hydroxyl proton of **2** ( $\delta$  4.63 s) showed connectivities with the carbonyl carbon of the aryl ketone ( $\delta$  199.4) and C-12, C-13, and C-21. All these results firmly established that the 2-oxopropan-1,3-diyl substituent bridges between the C-12 and C-14 positions and that, apart from the configuration, this compound possesses structure **2**.

Since the absolute configuration of the C-15 asymmetric center of **3** is known,<sup>8</sup> a series of NOE experiments established not only the relative configuration of the 2-oxopropan-1,3-diyl bridge but also the absolute configuration of **2**. Irradiation at  $\delta$  2.62 (H-13 $\beta$ ) produced NOE enhancements in the signals of HO-12 $\alpha$ , H-16 $\beta$ , H-21a, and H-23a, as well as in those of H-15 $\alpha$  and Me-17 (+1.4 and +4.1% NOE enhancement, respectively), whereas the signals of HO-12 $\alpha$ , H-13 $\beta$ , H-21b, and H-23a were enhanced when H-21a ( $\delta$  2.77) was irradiated, thus establishing that all these protons are in close proximity of each other. Moreover, irradiation at H-15 $\alpha$  ( $\delta$  2.05) caused NOEs only of HO-12 $\alpha$ , H-16 $\alpha$  (+2.9%), H-16 $\beta$  (+0.6%), and Me-17, and not of H-13 $\beta$ , thus confirming that H-13 $\beta$  and H-15 $\alpha$  are on opposite sides of the tetrahydrofuran ring of **2**. Finally, irradiation at  $\delta$  1.21 (where both Me-17 and one of the C-4 methyl groups resonate) produced NOEs of H-13 $\beta$ , H-15 $\alpha$ , and H-16 $\beta$ , together with those observed in H-6, H<sub>2</sub>-3, and C-4 methyl (at  $\delta$  1.28), which were caused by the irradiation of the C-4 methyl substituent ( $\delta$  1.22). All these NOE experiments established that Me-17 and the C-21–C-23 bridge of **2** are *cis* oriented and that the orientation of H-13 is  $\beta$ .

A chair (<sup>13</sup>C<sub>22</sub>) conformation was established for the six-membered ring involving C-12–C-14 and C-21–C-23 of **2**. H-21a and H-23a ( $\delta$  2.77 and 2.92, respectively), which are close to H-13 $\beta$  (see above), appeared as doublets ( $J_{\text{gem}}$  = 17.0 and 14.5 Hz, respectively) in the <sup>1</sup>H NMR spectrum of **2**, whereas their methylene partners ( $\delta$  2.53 and 2.86, respectively) resonated as double doublets, showing a reciprocal long-range coupling (<sup>4</sup> $J$  = 1.5 Hz), which is typical for 1,3-diequatorial protons coupled through a carbonyl group.<sup>30</sup> These data support a chair (<sup>13</sup>C<sub>22</sub>) conformation and establish that H-21a and H-23a (pro-*S* and pro-*R* hydrogens, respectively) are axially oriented and H-21b and H-23b (pro-*R* and pro-*S* hydrogens, respectively) possess an equatorial orientation. Moreover, NOE experiments were also in agreement with these conclusions because irradiation at  $\delta$  2.77 (axial H-21a) produced, among others, NOEs in the H-23a and H-13 $\beta$  1,3-diaxial protons, and irradiation at  $\delta$  2.53 (equatorial H-21b) did not cause NOEs in any of the 23-methylene protons.

It was not possible to establish the configurations of the C-1–C-3 methylene protons of **2** because H-1b, H<sub>2</sub>-2, and H<sub>2</sub>-3 overlapped. The observed vicinal coupling constants for the pseudoaxial H-1a proton ( $\delta$  3.19,  $J_{\text{a,a'}}$  = 9.8 Hz,  $J_{\text{a,e'}}$  = 5.8 Hz) are compatible with two possible half-chair (<sup>2</sup>HC<sub>3</sub> and <sup>3</sup>HC<sub>2</sub>) conformations for ring A. In a <sup>2</sup>HC<sub>3</sub> conforma-

**Scheme 1.** Formation of Compound **2** from Cryptotanshinone (**3**)

tion, the signal at  $\delta$  3.19 must be assigned to the pseudoaxial proton possessing an  $\alpha$ -orientation, whereas that signal must be ascribed to the pseudoaxial  $1\beta$ -proton when ring A possesses a  $^3\text{HC}_2$  conformation. This ambiguity also precludes the assignment of the methyl groups attached to the C-4 carbon (Me-18 and Me-19:  $\delta_{\text{H}}$  1.28 and 1.22,  $\delta_{\text{C}}$  31.85 and 31.87). It seems that ring A of **2** does not possess a half-boat ( $^1\text{H}_\text{B}$  or  $\text{HB}_{1,4}$ ) conformation, because no NOE was observed in any of the signals of the Me-18 and Me-19 groups when the pseudoaxial H-1a proton was irradiated. In any case, the possibility of a conformational equilibrium between  $^2\text{HC}_3$  and  $^3\text{HC}_2$  conformations in ring A of **2** could not be discarded.<sup>31</sup>

The transformation of cryptotanshinone (**3**) into **2** under basic conditions may be rationalized by the mechanistic pathway shown in Scheme 1, which implies a Robinson annelation reaction. A stereoselective attack of a carbanion arising from acetone on the C-14 position of **3** could produce the intermediate A, which is stereoselectively transformed into the Michael adduct B. Finally, an intramolecular cyclization of B affords **2** by an aldol condensation reaction between a carbanion at C-21 and the C-12 carbonyl group.

## Experimental Section

**General Experimental Procedures.** Melting points were determined on a Kofler block and are uncorrected. Optical rotations were measured on a Perkin-Elmer 241 MC polarimeter. UV spectra were recorded on a Perkin-Elmer Lambda 2 UV/vis spectrophotometer. IR spectra were obtained on a Perkin-Elmer Spectrum One spectrophotometer.  $^1\text{H}$  and  $^{13}\text{C}$  NMR spectra were recorded in  $\text{CDCl}_3$  solution on a Varian INOVA 400 apparatus at 400 and 100 MHz, respectively. Chemical shifts are given on the  $\delta$  scale and were referenced to residual  $\text{CHCl}_3$  at 7.25 ppm for proton and to the solvent at 77.00 ppm for carbon. All the assignments for protons and carbons were in agreement with 2D COSY, TOCSY, gHSQC, gHMBC, and 1D NOESY spectra. Mass spectra were registered in the positive EI mode on a Hewlett-Packard 5973 instrument (70 eV). Elemental analyses were conducted on a Carlo Erba EA 1108 apparatus. Merck Si gel (70–230 mesh and 230–400 mesh, for gravity flow and flash chromatography, respectively) was used for column chromatography. Merck 5554 Kieselgel 60 F<sub>254</sub> sheets were used for TLC analysis. Petroleum ether (bp 50–70 °C) was used for column chromatography. HPLC analyses were performed on an apparatus

equipped with a Merck Hitachi Lachrom 7100 pump, a Merck Hitachi D7500 integrator, and a Spectro-Physics Spectro-Chrom 100 UV detector ( $\lambda$  432 nm). A Merck Lichrocart (125  $\times$  4 mm) column with Lichrospher 100 RP-18 (5  $\mu\text{m}$ ) as stationary phase and 9:1 acetonitrile–water as mobile phase (flow rate 1 mL/min) was used.

**Plant Material.** *P. grandidentatus* Gürke was cultivated in the Faculty of Pharmacy Hortum, Lisbon University, from seeds provided by the National Botanic Garden, Kirstenbosh, Claremont, South Africa. The plants were cultivated through vegetative propagation of the first specimen obtained from seed. The material was collected in July–October 1997, and voucher specimens were deposited in the Herbarium of the Botanical Center of the “Instituto de Investigação Científica Tropical”, Lisbon (ref. C. Marques, S/No. LISC).

**Extraction and Isolation.** Dried and powdered *P. grandidentatus* aerial parts (6.91 kg) were extracted with  $\text{Me}_2\text{CO}$  (3  $\times$  25 L) at room temperature for 8 days. The solvent was evaporated under reduced pressure and low temperature (40 °C), yielding a residue (306.7 g). A part (150 g) of the total extract was subjected to column chromatography (Si gel 70–230 mesh, 1.5 kg) eluting successively with petroleum ether, petroleum ether–EtOAc (9:1, 4:1, 2:1, 1:1, and 1:4), EtOAc, 1:1 EtOAc–MeOH, and MeOH. The residue (9.26 g) of the fractions eluted with 9:1 petroleum ether–EtOAc was crystallized from 19:1 petroleum ether–EtOAc, giving pure 7 $\alpha$ -acetoxy-6 $\beta$ -hydroxyroyleanone<sup>5,10–12</sup> (7 $\alpha$ -acetoxy-6 $\beta$ ,12-dihydroxyabieta-8,12-diene-11,14-dione, 3.32 g, 0.098% on dry plant material). The residue (5.72 g) obtained after evaporation of the mother liquors from the crystallization was rechromatographed (Si gel 230–400 mesh column, 340 g, eluted with a petroleum ether– $\text{CH}_2\text{Cl}_2$  gradient from 12:1 to 4:1), yielding, in order of increasing chromatographic polarity, a mixture of fatty acid esters of tyrosol<sup>14</sup> [2-(4-hydroxyphenyl)ethyl *n*-alkanoates, 32 mg, 0.0009%], impure **1** (87 mg), additional quantities of 7 $\alpha$ -acetoxy-6 $\beta$ -hydroxyroyleanone (1.43 g, 0.042%), and coleon U<sup>6,11–13</sup> (6,11,12,14-tetrahydroxyabieta-5,8,11,13-tetraen-7-one, 7 mg, 0.0002%). Repeated crystallizations of impure **1** from *n*-pentane furnished a pure sample of **1** (25.6 mg, 0.0007%).

The previously known compounds (fatty acid esters of tyrosol,<sup>14</sup> 7 $\alpha$ -acetoxy-6 $\beta$ -hydroxyroyleanone,<sup>5,10–12</sup> and coleon U<sup>6,11–13</sup>) were identified by their physical (mp,  $[\alpha]_{\text{D}}$ ) and spectroscopic ( $^1\text{H}$  NMR, MS) data and by comparison (TLC) with authentic samples.

**6,12,14-Trihydroxy-9 $\alpha$ -(2-oxopropyl)abieta-5,8(14),12-triene-7,11-dione (1):** yellow fine needles (*n*-pentane); mp 169–171 °C;  $[\alpha]_{\text{D}}^{25} -694.6^\circ$  (*c* 0.168,  $\text{CHCl}_3$ ); UV (MeOH)  $\lambda_{\text{max}}$  (log  $\epsilon$ ) 234 (3.90), 276 (3.99), 316 (3.96), 434 (3.95) nm; IR (KBr)  $\nu_{\text{max}}$  3412, 3325, 2961, 2927, 1724, 1652, 1561, 1397, 1359, 1293, 1211, 1146, 1037, 871, 774, 702, 654  $\text{cm}^{-1}$ ;  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 400 MHz)  $\delta$  14.59 (1H, s, HO-14), 7.39 (1H, s, HO-12), 6.62 (1H, s, HO-6), 3.39 (1H, sept,  $J = 7.1$  Hz, H-15), 3.37 (1H, d,  $J_{\text{gem}} = 16.7$  Hz, H-21a), 3.23 (1H, d,  $J_{\text{gem}} = 16.7$  Hz, H-21b), 1.94 (3H, s, Me-23), 1.78 (2H, m,  $^* \text{H-1}\alpha$  and  $\text{H-1}\beta$ ),<sup>32</sup> 1.64 (1H, m,  $^* \text{H-2}\beta$ ), 1.56 (1H, m,  $^* \text{H-2}\alpha$ ), 1.55 (1H, m,  $^* \text{H-3}\beta$ ), 1.45 (3H, s, Me-18), 1.43 (1H, ddd,  $J_{3\alpha,3\beta} = 14.0$  Hz,  $J_{3\alpha,2\alpha} = 2.4$  Hz,  $J_{3\alpha,2\beta} = 10.8$  Hz, H-3 $\alpha$ ), 1.34 (3H, d,  $J = 7.1$  Hz, Me-16 or Me-17), 1.33 (3H, d,  $J = 7.1$  Hz, Me-17 or Me-16), 1.22 (3H, s, Me-19), 0.93 (3H, s, Me-20);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz)  $\delta$  204.9 (C, C-22), 196.4 (C, C-11), 179.3 (C, C-7), 171.5 (C, C-14), 152.7 (C, C-12), 143.2 (C, C-6), 139.9 (C, C-5), 127.9 (C, C-13), 106.2 (C, C-8), 53.8 (C, C-9), 52.9 ( $\text{CH}_2$ , C-21), 46.3 (C, C-10), 41.0 ( $\text{CH}_2$ , C-3), 35.8 (C, C-4), 31.1 ( $\text{CH}_2$ , C-1), 30.3 ( $\text{CH}_3$ , C-18), 30.1 ( $\text{CH}_3$ , C-23), 27.4 ( $\text{CH}_3$ , C-19), 24.9 ( $\text{CH}$ , C-15), 24.0 ( $\text{CH}_3$ , C-20), 19.7 ( $\text{CH}_3$ , C-16 or C-17), 19.3 ( $\text{CH}_3$ , C-17 or C-16), 17.6 ( $\text{CH}_2$ , C-2); EIMS  $m/z$  403  $[\text{M}]^+$  (8), 387 (1), 384 (1), 369 (1), 359 (1), 345 (1), 251 (85), 233 (4), 223 (22), 151 (100), 123 (21), 111 (5), 91 (4), 81 (11), 69 (5), 67 (4), 55 (5), 43 (14), 41 (5); *anal.* C 68.71%, H 7.60%, calcd for  $\text{C}_{23}\text{H}_{30}\text{O}_6$ , C 68.63%, H 7.51%.

**Identification of Compound 1 in a New Plant Extract by HPLC.** *P. grandidentatus* aerial parts (131.5 g, with the same origin as the material used for the extraction with  $\text{Me}_2\text{CO}$

CO) were extracted with  $\text{CHCl}_3$  for spectroscopy (Merck ref. 1.02447,  $3 \times 300$  mL) at room temperature for 8 days. Filtration and evaporation (470 mbar,  $40^\circ\text{C}$ ) of the solvent gave a residue (3.07 g). A part (1.5 g) of this extract was subjected to chromatography (Si gel 230–400 mesh column, 80 g) eluting with petroleum ether (PRA grade, 99.5%  $\text{C}_6$  isomers, free of  $\text{Me}_2\text{CO}$ ) and petroleum ether–EtOAc (CHROMASOLV Plus, for HPLC, 99.9%, free of acetone) 9:1, 4:1, and 1:1 mixtures. The fractions eluted with 4:1 petroleum ether–EtOAc contained compounds with polarities similar (TLC) to that of **1**. Alternately, the remaining sample (1.57 g) of the total extract was digested with 9:1 petroleum ether–EtOAc (30 mL) at room temperature for 5 h. The soluble fraction was very similar (TLC) to that obtained by chromatography. Both these fractions were subjected to HPLC analysis (see General Experimental Procedures), and in both cases a peak with a retention time 2.5 min (identical to that of an authentic sample of **1**) was observed. HPLC of a mixture of authentic **1** and each one of the above fractions showed an enhanced peak at  $t_R$  2.5 min. The mobile phase (9:1 acetonitrile–water) for the HPLC analyses was free of  $\text{Me}_2\text{CO}$  (analytical grade solvents).

**Treatment of Cryptotanshinone (3) with Acetone under Basic Conditions.** To a stirred solution of **3**<sup>8,9</sup> (23 mg, 0.077 mmol) in EtOH (8 mL) were successively added  $\text{Me}_2\text{CO}$  (2 mL) and an EtOH solution of KOH (10%, w/v, 2 mL, 3.56 mmol), and the reaction mixture was stirred at room temperature for 8 min. Then, water (20 mL) was added and the mixture was extracted with  $\text{CH}_2\text{Cl}_2$  ( $4 \times 15$  mL). The extracts were dried ( $\text{Na}_2\text{SO}_4$ ) and filtered, and the solvents were removed, giving a residue (23 mg), which was chromatographed (Si gel 230–400 mesh column, 7 g, eluted with 4:1 petroleum ether–EtOAc), yielding pure **2** (17 mg, 0.048 mmol, 61.8%), less polar (TLC, 4:1 petroleum ether–EtOAc as eluent) than the starting material (**3**).

**(12R,13S,14S,15R)-14,16-Epoxy-12 $\alpha$ -hydroxy-12 $\beta$ ,14 $\beta$ -(2-oxopropan-1,3-diyl)-20-nor-abieta-5(10),6,8-trien-11-one (2):** rectangular white plates (EtOAc–*n*-pentane); mp  $258\text{--}261^\circ\text{C}$ ;  $[\alpha]_D^{24} -44.5^\circ$  ( $c$  0.137,  $\text{CHCl}_3$ ); UV (MeOH)  $\lambda_{\text{max}}$  (log  $\epsilon$ ) 215 (4.43), 258 (4.07), 308 (3.51) nm; IR (KBr)  $\nu_{\text{max}}$  3424, 3101, 2959, 2929, 1721, 1677, 1590, 1267, 1228, 1126, 1045, 974, 942, 852  $\text{cm}^{-1}$ ;  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 400 MHz)  $\delta$  7.63 (1H, d,  $J = 8.4$  Hz, H-6), 7.42 (1H, d,  $J = 8.4$  Hz, H-7), 4.63 (1H, s, HO-12 $\alpha$ ), 3.90 (1H, t,  $J_{\text{gem}} = J_{16\alpha,15\alpha} = 8.6$  Hz, H-16 $\alpha$ ), 3.59 (1H, dd,  $J_{\text{gem}} = 8.6$  Hz,  $J_{16\beta,15\alpha} = 7.3$  Hz, H-16 $\beta$ ), 3.19 (1H, ddd,  $J_{\text{gem}} = 15.4$  Hz,  $J_{a,a'} = 9.8$  Hz,  $J_{a,e'} = 5.8$  Hz, axial H-1a), 2.92 (1H, d,  $J_{\text{gem}} = 14.5$  Hz, axial pro-*R* H-23a), 2.90 (1H, m, equatorial H-1b), 2.86 (1H, dd,  $J_{\text{gem}} = 14.5$  Hz,  $J_{23b,21b} = 1.5$  Hz, equatorial pro-*S* H-23b), 2.77 (1H, d,  $J_{\text{gem}} = 17.0$  Hz, axial pro-*S* H-21a), 2.62 (1H, d,  $J_{13\beta,15\alpha} = 10.5$  Hz, H-13 $\beta$ ), 2.53 (1H, dd,  $J_{\text{gem}} = 17.0$  Hz,  $J_{21b,23b} = 1.5$  Hz, equatorial pro-*R* H-21b), 2.05 (1H, dddq,  $J_{15\alpha,13\beta} = 10.5$  Hz,  $J_{15\alpha,16\alpha} = 8.6$  Hz,  $J_{15\alpha,16\beta} = 7.3$  Hz,  $J_{15\alpha,17} = 6.8$  Hz, H-15 $\alpha$ ), 1.83 (1H, m, H-2a), 1.66 (1H, m, H-2b), 1.60 (2H, m, H-3), 1.28 (3H, s, Me-18 or Me-19), 1.22 (3H, s, Me-19 or Me-18), 1.21 (3H, d,  $J_{17,15\alpha} = 6.8$  Hz, Me-17);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz)  $\delta$  204.5 (C, C-22), 199.4 (C, C-11), 147.6 (C, C-5), 145.0 (C, C-8), 140.2 (C, C-10), 134.7 (CH, C-6), 124.9 (C, C-9), 124.2 (CH, C-7), 82.3 (C, C-14), 76.1 (C, C-12), 75.2 ( $\text{CH}_2$ , C-16), 61.6 (CH, C-13), 54.8 ( $\text{CH}_2$ , C-23), 52.6 ( $\text{CH}_2$ , C-21), 38.0 ( $\text{CH}_2$ , C-3), 34.4 (CH, C-15), 34.2 (C, C-4), 31.87 ( $\text{CH}_3$ , C-18 or C-19), 31.85 ( $\text{CH}_3$ , C-19 or C-18), 30.0 ( $\text{CH}_2$ , C-1), 19.3 ( $\text{CH}_2$ , C-2), 18.6 ( $\text{CH}_3$ , C-17); EIMS  $m/z$  354 [ $\text{M}]^+$  (100), 336 (63), 321 (13), 308 (16), 294 (39), 291 (93), 266 (29), 251 (31), 237 (30), 223 (21), 165 (18), 141 (13), 128 (15), 115 (11), 83 (8), 69 (6), 55 (7), 43 (7), 41 (5); anal. C 74.71%, H 7.26%, calcd for  $\text{C}_{22}\text{H}_{26}\text{O}_4$ , C 74.55%, H 7.39%.

**Attempts at Obtaining Michael Adducts from 7 $\alpha$ -Acetoxyroyleanone (5) and Acetone.** Treatment of **5**,<sup>23–25</sup> as described above for obtaining **2**, yielded the starting material (**5**) and minute amounts (>4%) of horminone (**6**),<sup>24,25</sup> identified by comparison (TLC, UV, and MS) with an authentic sample.<sup>5</sup>

When a solution of **5** (39 mg, 0.026 mmol) in MeOH– $\text{Me}_2\text{CO}$  (2:1, v/v, 30 mL) was treated with *K*-*t*-BuO (19 mg, 0.168

mmol) at room temperature for 48 h, the starting material (**5**) was recovered unchanged.

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## References and Notes

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