

## FUROEREMOPHILANES AND OTHER CONSTITUENTS FROM CHILEAN *SENECIO* SPECIES

J. JAKUPOVIC, M. GRENZ, F. BOHLMANN and H. M. NIEMEYER\*

Institute for Organic Chemistry, Technical University of Berlin, D-1000 Berlin 12, Germany; \*Facultad de Ciencias, Universidad de Chile, Santiago, Casilla 653, Chile

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**Key Word Index**—*Senecio subumbellatus*, *S. portalesianus*, *S. zapahuirensis*, *S. philippicus*, *S. olivaceobracteatus*; Compositae; sesquiterpenes; furoeremophilanes; eremophilanes; acylpyrrol derivative.

**Abstract**—Investigation of five further Chilean *Senecio* species afforded, in addition to known compounds, four new furoeremophilanes, four eremophilanes, a germacatrienol and an acylpyrrol derivative. Structures were elucidated by high field NMR techniques.

### INTRODUCTION

As a part of our studies of the chemistry of the large genus *Senecio*, we have investigated several species from Chile [1]. We now report the results for five further species.

### RESULTS AND DISCUSSION

The aerial parts of *S. subumbellatus* Phil. gave germacrene D, phytol, spathulenol and the furoeremophilanes 1–4. The structures of 1–3 were readily deduced from their <sup>1</sup>H NMR spectra (Table 1) which were close to those of similar diesters [2]. The relative positions of the ester groups followed from the unchanged chemical shift of H-3. In the spectrum of 4 (Table 1) the shift of H-6 was nearly the same as that of the isovalerate 2, while the signal of H-3 was upfield shifted. Accordingly, the 3-desacetyl derivative of 2 was present.

The aerial parts of *S. olivaceobracteatus* Ric. et Martic. gave the known furoeremophilanes 5 [3], 6 [4], 7 [5], 10 [3], 11 [6] and 12 [6] while those of *S. zapahuirensis* Martic. et Quez. afforded caryophyllene, its epoxide, 5 [3], 8 [7] and 9 [3]. The aerial parts of *S. portalesianus* Remy. gave the eremophilanes 13–16, phytol and the acylpyrrols 17 and 18 [8]. The structures of 13 and 14 followed from their <sup>1</sup>H NMR spectra (Table 2). Spin decoupling allowed the assignment of nearly all signals, only a few being overlapped multiplets. The resulting sequences required the proposed substitution pattern, and the observed couplings indicated the stereochemistry given from inspection of the model. The coupling of H-1 is typical for β-epoxides as in ketone 8 and related compounds, where the configuration is known.

The <sup>1</sup>H NMR spectra of 15 and 16 (Table 2) indicated that these compounds differ only in the nature of the ester groups. Spin decoupling led to the proposed substitution. The presence of *trans*-decalin derivatives followed from the coupling  $J_{1,10}$ . Furthermore, NOED established this proposal [H-14 with H-8 (6%) and H-1 (7%); H-7 with H-10 (5%)]. A small NOE between H-1 and OAc (1%) further indicated that the acetoxy group is at C-1. The

observed couplings also showed that the cyclohexanone ring is in a boat conformation. The <sup>1</sup>H NMR spectrum of 17 (Experimental) clearly showed that we were dealing with the desacetyl derivative of 18. The 7-*epi* isomer has been isolated previously [8].

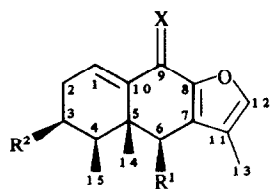
The aerial parts of *S. philippicus* Regel et Koern. gave germacrene D, the ketone 20 and the germacatriene derivative 19. The <sup>1</sup>H NMR spectrum at room temperature was highly broadened but at elevated temperature all signals could be assigned by spin decoupling. The resulting sequence only agrees with the proposed structure. The coupling of H-1 indicated that most likely a β-hydroxy derivative was present.

The chemistry of the five further Chilean *Senecio* species shows no clear difference to that of *Senecio* species

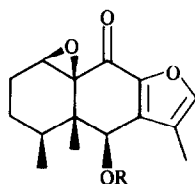
Table 1. <sup>1</sup>H NMR spectral data of compounds 1–4 (400 MHz, CDCl<sub>3</sub>, δ-values)

H	1	2	3	4	
1	5.54	5.53	5.53	5.54	<i>dt</i>
3	5.17	5.18	5.16	4.25	<i>ddd</i>
6	6.18	6.18	6.24	6.15	<i>dd</i>
9	3.40	3.40	3.40	3.39	<i>br d</i>
9'	3.05	3.04	3.04	3.03	<i>d</i>
12	7.03	7.02	7.03	7.03	<i>br s</i>
13	1.82	1.82	1.82	1.83	<i>d</i>
14	1.10	1.10	1.12	1.09	<i>s</i>
15	0.95	0.94	0.95	0.90	<i>d</i>
OCOR	2.42 <i>q</i> 1.21 <i>t</i>	2.28 <i>dd</i> 2.20 <i>dd</i> 2.12 <i>m</i>	2.66 <i>qq</i> 1.23 <i>d</i>	2.34 <i>dd</i> 2.26 <i>dd</i> 2.11 <i>m</i>	
OAc	2.05	2.04	2.05	—	<i>s</i>

$J$  [Hz]: 1, 2 = 5; 1, 2' = 1, 9 = 2; 4, 15 = 7; 6, 9 = 2.5; 6, 9' ~ 1; 9, 9' = 17; 12, 13 = 1.5; OProp: 2, 3 = 7.5; OiVal: 2, 2' = 13; 2, 3 = 2', 3 = 3, 4 = 3, 5 ~ 7; OiBu: 2, 3 = 2, 4 = 7.

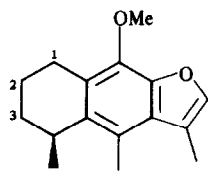


	1	2	3	4	5	6	7
R <sup>1</sup>	OProp	OiVal	OiBu	OiVal	H	OiBu	OProp
R <sup>2</sup>	OAc	OAc	OAc	OH	H	H	H
X	H <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub>	O	O	O



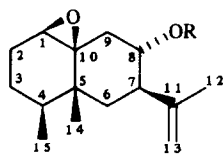
**8** R = *i*Bu

**9** R = Ac



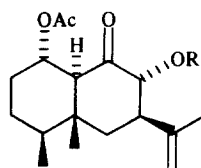
**10** **11** Δ<sup>1</sup>

**12** Δ<sup>1,3</sup>



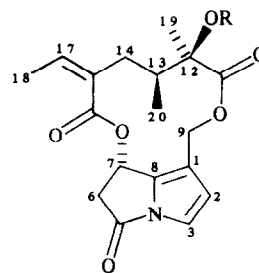
**13** R = Tigl

**14** R = Ang



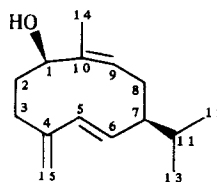
**15** R = Ang

**16** R = Tigl

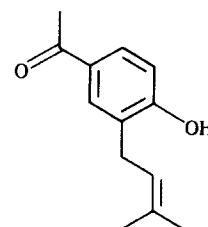


**17** R = H

**18** R = Ac



**19**



**20**

from other parts of the world. Again the chemistry is not very uniform though eremophilanes and derived furo-eremophilanes are present in all species except one.

#### EXPERIMENTAL

The air-dried aerial parts were extracted with MeOH-petrol-Et<sub>2</sub>O (1:1:1). The extracts obtained were sepd as reported previously [9]. The isolated compounds are summarized in Table 3. Known compounds were identified by comparing the 400 MHz <sup>1</sup>H NMR spectra with those of authentic material.

**3β-Acetoxy-6β-propionyloxyeremophilin (1).** IR ν<sub>max</sub><sup>CCl<sub>4</sub></sup> cm<sup>-1</sup>: 1750 (CO<sub>2</sub>R); MS *m/z* (rel. int.): 346.178 [M-HOAc]<sup>+</sup> (1.5) (calc. for C<sub>20</sub>H<sub>26</sub>O<sub>5</sub>: 346.178), 272 [346-EtCO<sub>2</sub>H]<sup>+</sup> (22), 220 (20), 215 (100), 159 (82), 119 (98), 93 (86), 69 (85), 57 (60); [α]<sub>D</sub><sup>24</sup> +11 (CHCl<sub>3</sub>; c 0.15).

**3β-Acetoxy-6β-isovaleryloxyeremophilin (2).** IR ν<sub>max</sub><sup>CCl<sub>4</sub></sup> cm<sup>-1</sup>: 1745 (CO<sub>2</sub>R); MS *m/z* (rel. int.): 374.209 [M]<sup>+</sup> (0.8) (calc. for C<sub>22</sub>H<sub>30</sub>O<sub>5</sub>: 374.209), 272 [M-iValOH]<sup>+</sup> (39), 212 [272-HOAc]<sup>+</sup> (71), 197 [212-Me]<sup>+</sup> (70), 123 (100), 85 (80); [α]<sub>D</sub><sup>24</sup> -33 (CHCl<sub>3</sub>; c 0.1).

**3β-Acetoxy-6β-isobutyryloxyeremophilin (3).** IR ν<sub>max</sub><sup>CCl<sub>4</sub></sup> cm<sup>-1</sup>: 1750 (CO<sub>2</sub>R); MS *m/z* (rel. int.): 360.194 [M]<sup>+</sup> (1) (calc. for C<sub>21</sub>H<sub>28</sub>O<sub>5</sub>: 360.194), 272 [M-RCO<sub>2</sub>H]<sup>+</sup> (10), 212 [272-HOAc]<sup>+</sup> (35), 123 (46), 71 [RCO]<sup>+</sup> (100).

**3β-Hydroxy-6β-isovaleryloxyeremophilin (4).** IR ν<sub>max</sub><sup>CCl<sub>4</sub></sup> cm<sup>-1</sup>: 3620 (OH), 1740 (CO<sub>2</sub>R); MS *m/z* (rel. int.): 332.199 [M]<sup>+</sup> (4) (calc. for C<sub>20</sub>H<sub>28</sub>O<sub>4</sub>: 332.199), 230 [M-RCO<sub>2</sub>H]<sup>+</sup> (100), 215 [230-Me]<sup>+</sup> (63), 212 [230-H<sub>2</sub>O]<sup>+</sup> (73), 197 [212-Me]<sup>+</sup> (70), 123 (88), 85 (91); [α]<sub>D</sub><sup>24</sup> +10 (CHCl<sub>3</sub>; c 0.6).

**8α-Tigloyloxy-1β,10β-epoxyeremophil-11(13)-ene (13).** IR ν<sub>max</sub><sup>CCl<sub>4</sub></sup> cm<sup>-1</sup>: 1720 (C=CCO<sub>2</sub>R); MS *m/z* (rel. int.): 318.219 [M]<sup>+</sup> (0.5) (calc. for C<sub>20</sub>H<sub>30</sub>O<sub>3</sub>: 318.219), 218 [M-RCO<sub>2</sub>H]<sup>+</sup> (12), 203 (8), 200 (9), 83 [RCO]<sup>+</sup> (100).

**8α-Angelyloxy-1β,10β-epoxyeremophil-11(13)-ene (14).** IR ν<sub>max</sub><sup>CCl<sub>4</sub></sup> cm<sup>-1</sup>: 1720 (C=CCO<sub>2</sub>R); MS *m/z* (rel. int.): 318.219 [M]<sup>+</sup> (0.7) (calc. for C<sub>20</sub>H<sub>30</sub>O<sub>3</sub>: 318.219), 218 [M-RCO<sub>2</sub>H]<sup>+</sup> (18), 83 [RCO]<sup>+</sup> (100).

Table 2. <sup>1</sup>H NMR spectral data of compounds 13–16 (CDCl<sub>3</sub>, 400 MHz, δ-values)

H	13	14	15	16
1	2.84 <i>br d</i>	2.86 <i>br d</i>	5.13 <i>dt</i>	5.12 <i>dt</i>
4	1.76 <i>m</i>	1.76 <i>m</i>	1.51 <i>m</i>	1.50 <i>m</i>
6	1.78 <i>m</i>		1.93 <i>m</i>	1.93 <i>m</i>
6'	1.61 <i>dd</i>	1.61 <i>dd</i>	1.78 <i>dd</i>	1.77 <i>m</i>
7	2.80 <i>ddd</i>	2.80 <i>ddd</i>	3.11 <i>ddd</i>	3.10 <i>ddd</i>
8	5.25 <i>ddd</i>	5.27 <i>ddd</i>	5.00 <i>d</i>	5.00 <i>d</i>
9	2.84 <i>dd</i>	2.88 <i>dd</i>	—	—
9'	1.21 <i>dd</i>	1.22 <i>m</i>	—	—
10	—	—	2.96 <i>d</i>	2.94 <i>d</i>
12	4.82 <i>br s</i>	4.82 <i>br s</i>	{ 4.90 <i>br s</i> 4.85 <i>br s</i>	{ 4.90 <i>br s</i> 4.85 <i>br s</i>
13	1.72 <i>br s</i>	1.72 <i>br s</i>	1.74 <i>br s</i>	1.73 <i>br s</i>
14	1.00 <i>s</i>	1.00 <i>s</i>	0.81 <i>s</i>	0.81 <i>s</i>
15	0.74 <i>d</i>	0.74 <i>s</i>	0.86 <i>d</i>	0.86 <i>d</i>
OCOR	6.86 <i>qq</i> 1.80 <i>dq</i> 1.76 <i>dq</i>	6.03 <i>qq</i> 1.87 <i>dq</i> 1.86 <i>dq</i>	6.09 <i>qq</i> 1.96 <i>dq</i> 1.89 <i>dq</i>	6.87 <i>qq</i> 1.82 <i>dq</i> 1.79 <i>dq</i>
OAc	—	—	—	1.98 <i>s</i>

J[Hz]: Compounds 13 and 14: 1,2=4; 4,15=7; 6,6' =14; 6,7~2; 6',7=8.5; 7,8=9; 8,9=7; 8,9'=5; 9,9'=15; compounds 15 and 16: 1,2=1,10=10; 1,2'=5; 4,15=7; 6,6'=14; 6,7=6',7=7,8~8; OTigl and OAng: 3,4=7; 3,5=4,5~1.5.

Table 3. Constituents of the investigated species (final condition of purification in parentheses)

	Collected	Weight (g)	Constituents
<i>Senecio subumbellatus</i> (Voucher Niemeyer 8944)	February 1989 Region del Bio-Bio	830	10 mg germacrene D, 8 mg phytol, 3 mg spathulenol, 3 mg <b>1</b> (TLC1,† $R_f$ 0.5), 3 mg <b>2</b> (HP1,* $R_t$ 8.3 min), 6 mg <b>3</b> (HP1, $R_t$ 7.3 min), 6 mg <b>4</b> (HP1, $R_t$ 6.7 min)
<i>S. olivaceobracteatus</i> (Voucher Niemeyer 8979)	May 1989 Region de Tarapaca	410	1 g <b>5</b> , 1.5 g <b>6</b> , 50 mg <b>10</b> , 250 mg <b>11</b> , 250 mg <b>12</b>
<i>S. zapahuirensis</i> (Voucher Niemeyer 8954)	May 1989 Region de Tarapaca	290	10 mg caryophyllene, 10 mg 1,10-caryophyllenepoxide, 15 mg <b>5</b> , 25 mg <b>8</b> , 25 mg <b>9</b>
<i>S. portalesianus</i> (Voucher Niemeyer 8933)	February 1989 Region del Maule	390	3 mg <b>13</b> (TLC2, $R_f$ 0.75), 5 mg <b>14</b> (TLC2, $R_f$ 0.6), 5 mg <b>15</b> (TLC2, $R_f$ 0.5), 3 mg <b>16</b> (TLC2, $R_f$ 0.45), 4 mg <b>17</b> (HP2, $R_t$ 5.2 min), 10 mg <b>18</b> , 10 mg phytol
<i>S. philippicus</i> (Voucher Niemeyer AH18)	Region del Liberator Bernardo O-Higgins	30	5 mg germacrene D, 6 mg <b>19</b> , 8 mg <b>20</b>

† TLC1: Et<sub>2</sub>O–petrol (1:4); TLC2: Et<sub>2</sub>O–petrol (1:1).

\*HP1 (always RP 8, flow rate 3 ml min<sup>-1</sup>): MeOH–H<sub>2</sub>O, 9:1; HP2: MeOH–H<sub>2</sub>O (4:1).

1 $\alpha$ -Acetoxy-8 $\alpha$ -angeloyloxy-10 $\alpha$ H-eremophil-11(13)-en-9-one (**15**). IR  $\nu_{\max}^{\text{CCl}_4}$  cm<sup>-1</sup>: 1740 (C=O, CO<sub>2</sub>R); MS  $m/z$  (rel. int.): 376.225 [M]<sup>+</sup> (0.3) (calc. for C<sub>22</sub>H<sub>32</sub>O<sub>5</sub>: 376.225), 316 [M–HOAc]<sup>+</sup> (1), 277 [M–OCOR]<sup>+</sup> (5), 216 [316–RCO<sub>2</sub>H]<sup>+</sup> (92), 201 (22), 83 [RCO]<sup>+</sup> (100); [ $\alpha$ ]<sub>D</sub> +12 (CHCl<sub>3</sub>; c 0.5).

1 $\alpha$ -Acetoxy-8 $\alpha$ -tigloyloxy-10 $\alpha$ H-eremophil-11(13)-en-9-one (**16**). IR  $\nu_{\max}^{\text{CCl}_4}$  cm<sup>-1</sup>: 1740 (C=O, CO<sub>2</sub>R); MS  $m/z$  (rel. int.): 376 [M]<sup>+</sup> (0.1), 316.204 [M–HOAc]<sup>+</sup> (1) (calc. for C<sub>20</sub>H<sub>28</sub>O<sub>3</sub>: 316.204), 216 [316–RCO<sub>2</sub>H]<sup>+</sup> (92), 201 (32), 109 (42), 83 [RCO]<sup>+</sup> (100), 55 [83–CO]<sup>+</sup> (88).

7-epi-Desacetylsenaetnin (**17**). IR  $\nu_{\max}^{\text{CHCl}_3}$  cm<sup>-1</sup>: 3600 (OH), 1760 (C=O), 1725 (C=CCO<sub>2</sub>R); MS  $m/z$  (rel. int.): 347.137 [M]<sup>+</sup> (4) (calc. for C<sub>18</sub>H<sub>21</sub>NO<sub>6</sub>: 347.137), 199 (17), 133 (100), 105 (52), 81 [RCO]<sup>+</sup> (27); <sup>1</sup>H NMR (CDCl<sub>3</sub>):  $\delta$  6.48 (*d*,  $J$  = 2 Hz, H-2), 7.13 (*d*,  $J$  = 3 Hz, H-3), 3.65 (*dd*,  $J$  = 19, 6.5 Hz, H-6), 3.00 (*dd*,  $J$  = 19, 2 Hz, H-6'), 5.86 (*dd*,  $J$  = 7, 2 Hz, H-7), 5.51 and 5.93 (*d*,  $J$  = 13.5 Hz, H-9), 5.96 (*br q*,  $J$  = 7 Hz, H-17), 1.97 (*dd*,  $J$  = 7, 2 Hz, H-18), 0.96 (*d*,  $J$  = 7 Hz, H-19), 1.37 (*s*, H-20); [ $\alpha$ ]<sub>D</sub><sup>24</sup> –31 (CHCl<sub>3</sub>; c 0.1).

1 $\beta$ -Hydroxygermacra-4(15),5E,9Z-triene (**19**). IR  $\nu_{\max}^{\text{CCl}_4}$  cm<sup>-1</sup>: 3600 (OH); MS  $m/z$  (rel. int.): 220 [M]<sup>+</sup> (6), 205 [M–Me]<sup>+</sup> (12), 202 [M–H<sub>2</sub>O]<sup>+</sup> (8), 123 (46), 109 (60), 95 (86), 81 (87), 69 (72), 55 (100); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 57°):  $\delta$  4.39 (*dd*,  $J$  = 9, 5 Hz, H-1), 1.87 (*m*, H-2), 2.44 and 2.20 (*m*, H-3), 5.58 (*d*,  $J$  = 16 Hz, H-5), 5.23 (*dd*,

$J$  = 16, 9 Hz, H-6), 1.63 (*m*, H-7), 2.20 and 1.87 (*m*, H-8), 5.16 (*ddq*,  $J$  = 10, 7, 1.5 Hz, H-9), 1.68 (*dq*,  $J$  = 7, 7 Hz, H-11), 0.99 and 0.98 (*d*,  $J$  = 7 Hz, H-12, H-13), 1.70 (*br s*, H-14), 4.87 and 4.81 (*br s*, H-15).

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