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FOUR OPLOPANONE AND BISABOLONE DERIVATIVES FROM *RUGELIA NUDICAULIS**

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Key Word Index—*Rugelia nudicaulis*; Compositae; Senecioneae; sesquiterpenes; oplopanone derivatives; bisabolone derivative.

Abstract—*Rugelia nudicaulis* afforded, in addition to known compounds, three new highly oxygenated oplopanone derivatives and a bisabolone derivative. The structures were elucidated by high field ^{1}H NMR spectroscopy. The chemotaxonomic situation is discussed briefly.

INTRODUCTION

The monotypic genus *Rugelia* was recently placed in the genus *Cacalia* [1]. We have therefore investigated *Rugelia nudicaulis* to see whether the chemistry supports this placement or shows relationships to any of the groups of the large genus *Senecio*.

RESULTS AND DISCUSSION

The roots of *R. nudicaulis* Shuttler ex Chapm. afforded germacrene A, α-humulene, α- and β-farnesene, α-zingiberene, bisabolene, β-sesquiphellandrene, α-bulnesene, anhydro-oplopanone (**1**) [2], platyphyllide (**6**) [3], phloracetophenone 2-methyl ether (**7**), the cinnamic acid derivatives **8** and **9**, the depside atranorin (**10**) [4] and the bisabolone derivative **5**. The structure of the latter followed from the ^{1}H NMR spectrum (Table 1) which was close to that of similar compounds [5]. The stereochemistry at C-1 followed from the coupling $J_{1,6}$, while the orientation of the epoxide was deduced by comparison with the chemical shifts of related epoxides [5]. The configuration at C-8 could not be determined. Furthermore, two derivatives of **1**, the diepoxides **3** and **4**, were present. The structure of **3** followed from the ^{1}H NMR spectral data (Table 1), which were in part similar to those of an abrotanifolone derivative isolated from *Senecio ovirensis* [6]. The signals of the olefinic methylene protons (H-10), however, were replaced by a pair of doublets and their chemical shift indicated the presence of an epoxide. Furthermore, an additional 2-methyl butyrate residue was deduced from the spectral data. The position of this ester group clearly followed from the missing signals for protons α to the keto group, while the stereochemistry was deduced from the coupling $J_{1,9}$. This substitution pattern is also present in a ketone isolated from *S. implexus* [7] where, however, the 8, 10-epoxide and the 4′-acetoxyl group are missing. The ^{1}H NMR spectrum of this compound was very close to that of **3**. The ^{1}H NMR spectrum of **4** clearly showed that this ketone was the 3, 14-dehydro derivative, as the signal of H-3 was missing and that of H-14 was replaced by an olefinic quartet. Again, a similar compound has been isolated from *Senecio implexus* [7]. The stereochemistry of the 3, 14-double bond followed from the chemical shift of H-15, while that at all other centers was the same as in **3**. The stereochemistry at C-8, C-11 and C-14 in **3** and **4** could not be determined. The aerial parts also gave germacrene A, α- and β-farnesene, bisabolene, **1**, **3–5** and a further oplopanone derivative, the dihydroxy ketone **2**. Again, the structures were deduced from the ^{1}H NMR spectral data (Table 1). Spin decoupling showed the presence of an isopropyl group, while the presence of a hydroxyl group at C-14 was indicated by a hydrogen bridge with the 2-keto group and the methyl doublet at δ 1.18, which was coupled with a broad multiplet at δ 4.05. Further spin decoupling allowed the assignment of all signals, though some were overlapping multiplets. The allylic position of the second hydroxyl group followed from the chemical shift of the corresponding signal of the proton under the hydroxyl group and from the downfield shift of one of the olefinic methylene signals, while the stereochemistry was deduced from the coupling $J_{6,7}$, which indicated a quasi-axial orientation. **2** was the *bis*-desacyl derivative of notonipetrone, which was isolated from *Notonia petraea* [8]. Compounds **1–5** indicated relationships of this species to a small section of the genus *Senecio* where the typical eremophilane and furanoeremophilane derivatives are missing [9]. The co-occurrence with the norsesquiterpene lactone **6**, which is rare in *Senecio* species, may also be important. Although *ca* 300 species from the tribe Senecioneae have been investigated, final conclusions about the position of *Rugelia* are difficult, especially as the taxonomy of

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*Part 437 in the series "Naturally Occurring Terpene Derivatives". For Part 436 see Bohlmann, F., Wallmeyer, M. and Jakupovic, J. (1982) *Phytochemistry* **21**, 1445.

Table 1. ^{1}H NMR spectral data of compounds **2–5** (400 MHz, $CDCl_3$, TMS as internal standard)

	2*	**3**(C_6D_6)	**4**	**5**
H-1	2.43 *dd* 2.16 *dd*	5.05 *d*	5.18*d*	5.86 *d*
H-3	2.52 *dd*	2.47 *m*	—	—
H-4		—	—	3.44 *br d*
H-5	1.4 *m*	—	—	2.62 *ddd* 2.21 *ddd*
H-6		5.60 *dd*	5.28 *dd*	2.78 *br dd*
H-6′	1.98 *dd*	—	—	
H-7	4.51 *br dd*	5.13 *d*	4.76 *d*	—
H-8	—	—	—	5.09 *dd*
H-9	2.80 *m*	2.47 *dd*	2.47 *dd*	2.33 *m*
H-10	4.99 *br s* 4.68 *br s*	2.87 *d* 2.63 *d*	2.96 *d* 2.76 *d*	5.04 *br t*
H-12	0.99 *d*	2.74 *br d* 2.61 *d*	2.84 *br d* 2.63 *d*	1.66 *br s*
H-13	0.74 *d*	1.20 *s*	1.61 *s*	1.59 *br s*
H-14	4.05 *m*	5.27 *dq*	6.55 *dq*	5.29 *br s* 5.08 *br s*
H-15	1.18 *d*	1.24 *d*	2.23 *dd*	1.46 *s*
OH	3.79 *d*	—	—	—
OCOR	—	5.87 *dq* 5.27 *br q* 1.33 *d* 2.16 *d*	5.89 *dq* 5.29 *br q* 1.38 *d* 2.12 *d*	6.11, 6.06 *qq* 2.01, 1.98 *dq* 1.91, 1.89 *dq*
OMeBu	—	2.50, 2.35 *tq* 1.67 *m* 1.45 *m* 0.94, 0.86 *t* 1.16, 1.15 *d*	2.37, 2.38 *tq* 1.68 *m* 1.47 *m* 0.92, 0.88 *t* 1.16, 1.12 *d*	— —
OAc	—	2.11 *s*	2.12 *s*	— —

*H-11 1.98 *m*.

J(Hz):Compound **2**: 1, 1′ = 14; 1, 9 = 6; 3, 4 = 10.5; 3, 14 = 4.5; 4, 5 = 11; 5, 6′ = 3; 6, 6′ = 14; 6′, 7 = 3; 7, 10 = 1.5; 11, 12 = 11, 13 = 7; 14, OH = 11; 14, 15 = 7; compound **3**: 1, 9 = 4.5; 3, 4 ~ 10; 3, 14 ~ 4; 4, 9 = 13; 5, 6 = 11; 6, 7 = 3.5; 10, 10′ = 4.5; 12, 12′ = 4; 14, 15 = 7; compound **4**: 1, 9 = 4.5; 4, 14 = 4, 15 = 2; 4, 9 = 13; 5,6 = 7; 6, 7 = 3.5; 10, 10′ = 4.5; 12, 12′ = 4; 14, 15 = 7; compound **5**: 1, 6 = 12.5; 4, 5 = 4; 5, 5′ = 15.5; 5, 6 = 7; 5′, 6 = 12; 8, 9 = 5; 8, 9′ = 8; 9, 10 = 7; OCOCH=C(Me)CH(OAc)Me: 2, 4 = 2, 6 ~ 1.3; 4, 5 = 7; OMeBu: 2, 3 = 2, 5 = 3, 4 = 7; OAng: 3′, 4′ = 7; 3′, 5′ = 4′, 5′ = 1.5.

the whole tribe is still being studied [10]. In structural details *Rugelia* is a member of the Cacaloid series, but the chemistry is not very similar to other members of the series such as *Adenostyles*, *Cacalia*, *Ligularia* and *Petasites* [7].

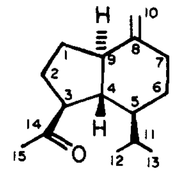
EXPERIMENTAL

The air-dried plant material (voucher deposited in the U.S. National Herbarium, Washington) was extracted with Et_2O–petrol, 1:2), and the resulting extracts separated by CC (Si gel) and further by repeated TLC (Si gel). Known compounds were identified by comparing the ^{1}H NMR spectra with those of authentic material. The roots (300 g) gave 100 mg germacrene A, 2 mg α-humulene, 5 mg bisabolene, 10 mg α- and 10 mg β-farnesene, 2 mg α-bulnesene, 5 mg β-sesquiphellandrene, 10 mg α-zingiberene, 50 mg **1**, 10 mg **3** (Et_2O–petrol, 3:1), 10 mg **4** (same solvent), 50 mg **6**, 2 mg **7**, 5 mg **8**, 10 mg **9** and 25 mg **10**, while the aerial parts (1 kg) gave 500 mg germacrene A, 100 mg α- and 100 mg β-farnesene, 50 mg bisabolene, 100 mg **1**, 5 mg **5** (Et_2O–petrol, 3:1), 50 mg **3**, 50 mg **4** and 100 mg **5** (Et_2O–petrol, 1:1).

7, 14-*Bisdesacylnotonipetrone* (**2**). Colourless gum, IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3620 (OH), 1735 (C=O); MS *m/z* (rel. int.): 234.162 $[M-H_2O]^+$ (7) ($C_{15}H_{22}O_2$), 216 $[234-H_2O]^+$ (6), 191 $[234-CHMe_2]^+$ (21), 173 $[191-H_2O]^+$ (16), 95 (74), 55 (100).

$$[\alpha]^{\lambda}_{24^\circ} = \frac{589 \quad 578 \quad 546 \quad 436\ \text{nm}}{-25 \quad -28 \quad -30 \quad -54} \quad (CHCl_3;\ c0.2).$$

4′-Acetoxy-1β-(2-methylbutyryloxy)-8, 10-epoxyabrotanifolone (**3**). Colourless gum, IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1745 (*br*) ($-CO_2R$, C=O, $C=CCO_2R$, OAc), 1650 (C=C), 1245 (OAc); MS *m/z* (rel. int.): 678.325 $[M]^+$ (0.15) ($C_{35}H_{50}O_{13}$), 618 $[M-HOAc]^+$ (1.7), 517 $[618-O_2CR]^+$ (0.8), 516 $[618-HO_2Cr]^+$ (0.1), 414 $[516-MeBuOH]^+$ (0.5), 362 $[414-\text{ketene}]^+$ (0.3), 344 $[516-HO_2CR']^+$ (0.4), 242 $[344-MeBuOH]^+$ (4), 155



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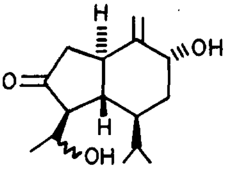

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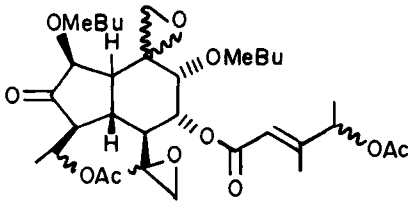

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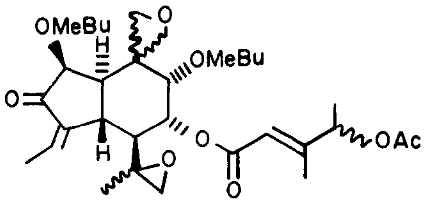

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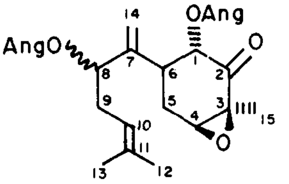

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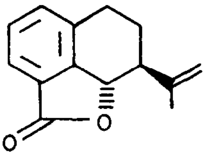

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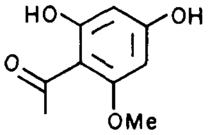

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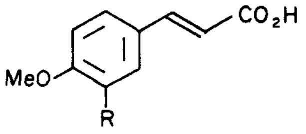
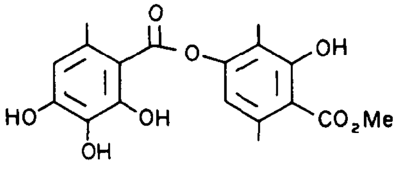


8 R = H

9 R = OMe



10

[O=CCH=C(Me)CH(OAc)Me]$^+$ (1), 113 [155 − ketene]$^+$ (58), 85 [C$_4$H$_9$CO]$^+$ (25), 57 [85 − CO]$^+$ (100).

$$[\alpha]^{\lambda}_{24°} = \frac{589 \quad 578 \quad 546 \quad 436\,\text{nm}}{-38 \quad -41 \quad -52 \quad -166} \quad (\text{CHCl}_3;\ c2.0).$$

4'-Acetoxy - 1β - (2 - methylbutyryloxy) - 14 - desacetoxy - 3, 14 - dehydro - 8, 10 - epoxyabrotanifolone (**4**). Colourless gum, IR $\nu^{\text{CCl}_4}_{\text{max}}$ cm^{-1}: 1750 (CO$_2$R, C=O, C=CCO$_2$R, OAc), 1650 (C=C), 1240 (OAc); MS *m/z* (rel. int.): 618.304 [M]$^+$ (3) (C$_{33}$H$_{46}$O$_{11}$), 517 (0.3), 516 (0.2), 447 (0.5), 344 (0.5), 242 (7), 155 (2), 113 (79), 85 (31), 57 (100).

$$[\alpha]^{\lambda}_{24°} = \frac{589 \quad 578 \quad 546 \quad 436\,\text{nm}}{-88 \quad -95 \quad -120 \quad -132} \quad (\text{CHCl}_3;\ c0.4).$$

1α, 8-Bisangeloyloxy-3β, 4β-epoxy-bisabola-7(14), 10-diene (**5**). Colourless gum, IR $\nu^{\text{CCl}_4}_{\text{max}}$ cm^{-1}: 1725 (C=O, C=CCO$_2$R); MS *m/z* (rel. int.): 430.234 [M]$^+$ (0.5) (C$_{25}$H$_{34}$O$_6$), 361 [M − C$_5$H$_9$]$^+$ (1), 330 [M − AngOH]$^+$ (15), 230 [330 − AngOH]$^+$ (3.5), 83 [C$_4$H$_7$CO]$^+$ (100).

$$[\alpha]^{\lambda}_{24°} = \frac{589 \quad 578 \quad 546 \quad 436\,\text{nm}}{-28 \quad -29 \quad -33 \quad -43} \quad (\text{CHCl}_3;\ c2.4).$$

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REFERENCES

1. Barkley, T. M. and Cronquist, A. (1974) *Rhodora* **76**, 48.
2. Bohlmann, F. and Zdero, C. (1978) *Phytochemistry* **17**, 1135.
3. Bohlmann, F., Knoll, K. H., Zdero, C., Mahanta, P. K., Grenz, M., Suwita, A., Ehlers, D., LeVan, N., Abraham, W. R. and Natu, A. A. (1979) *Phytochemistry* **16**, 965.
4. Pfau, A. S. (1926) *Helv. Chim. Acta* **9**, 650.
5. Bohlmann, F. and Zdero, C. (1978) *Phytochemistry* **17**, 1591.
6. Bohlmann, F. and Mahanta, P. K. (1979) *Phytochemistry* **18**, 678.
7. Bohlmann, F., Ahmed, M., Jakupovic, J. and Jeffrey, C. (1981) *Phytochemistry* **20**, 251.
8. Bohlmann, F. and Zdero, C. (1979) *Phytochemistry* **18**, 1063.
9. Bohlmann, F., Zdero, C., Berger, D., Suwita, A., Mahanta, P. K. and Jeffrey, C. (1979) *Phytochemistry* **18**, 79.
10. Jeffrey, C., Halliday, P., Wilmot-Dear, M. and Jones, S. U. (1977) *Kew Bull.* **32**, 47.