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EUDESMANOLIDES AND HELIANGOLIDES FROM *CALEA ROTUNDIFOLIA**

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Key Word Index—*Calea rotundifolia*; Compositae; sesquiterpene lactones; eudesmanolides; heliangolides; norterpene derivative.

Abstract—The aerial parts of *Calea rotundifolia* afforded, in addition to known compounds, heliangin and two further closely related lactones as well as three new eudesmanolides and a norterpene ketone. The structures were elucidated by spectroscopic methods. The chemotaxonomic situation is discussed briefly.

INTRODUCTION

The large New World genus *Calea* (tribe Heliantheae, Compositae) is placed in the subtribe Galinsoginae [1]. However, only part of this genus, which should be re-established as the genus *Alloisospermum*, showed chemical relationships of the typical representatives of this subtribe [2]. The main part of the genus should be placed away from the Galinsoginae, perhaps best in the Neurolaeninae [3]. We have now investigated a further species, *C. rotundifolia* (Less.) Baker, which again afforded several sesquiterpene lactones and no falcarinone-like compounds, which seem to be characteristic for *Alloisospermum* [2].

RESULTS AND DISCUSSION

The aerial parts of *C. rotundifolia* afforded germacrene D, α-humulene, bicyclogermacrene, caryophyllene, squalene, the chromenes **1** [4] and **2** [5], heliangin (**4**) [6] and minute amounts of a complex mixture of sesquiterpene lactones made up of the heliangolide **5**, the germacranolide **3** and the eudesmanolides **6–8**. Furthermore, a ketone was isolated, the norterpene **9**. The ^{1}H NMR data of **5** (Table 1) were close to those of **4**, only the H-3 signal being shifted downfield. **5** had already been prepared from heliangin (mp 179–181° [7]). Due to the small amount isolated, **5** and also the other lactones could not be induced to crystallize. The ^{1}H NMR spectrum of **3** (Table 1) showed the presence of a 4,5-*trans*-germacranolide with a 1,10-epoxide group and an 8-tiglinoyloxy residue, which was shown by irradiation of the H-7 signal. The small couplings of H-8 indicated a β-orientation of the ester group.

The ^{1}H NMR data of **6–8** (Table 2) showed that these lactones differed only in the position of the double bond. The presence of an 8β-tiglinoyloxy group followed from the small couplings of H-8, which was assigned by irradiation of the H-7 signal. The stereochemistry at C-1 was deduced from the large coupling $J_{1,2'}$. **6** is related to reynosin [8] and consequently the ^{1}H NMR data were similar. **7** is a derivative of arbusculin B [9], while **8** is the 8-desacyl derivative of balchanin [10]. The structure of **9** also followed from the spectroscopic data. The molecular formula, $C_9H_{14}O_2$, indicated a norterpene, while IR absorption bands at 3600 and 1730 cm^{-1} showed that it was a hydroxyketone. The ^{1}H NMR data (see

Table 1. ^{1}H NMR data of compounds **3–5** (270 MHz, $CDCl_3$, TMS as internal standard)

	3	4	5
H-1	2.76 *dd*	2.81 *dd*	2.86 *dd*
H-2	2.13 *d* (*br*)	2.47 *ddd*	2.58 *ddd*
H-2′	1.5 *dddd*	1.75 *ddd*	1.72 *ddd*
H-3	2.44 *ddd*	4.51 *dd* (*br*)	5.28 *dd*
H-3′	2.29 *ddd*		
H-5	5.37 *d* (*br*)	5.34 *dq*	5.31 *dq*
H-6	5.16 *dd*	6.67 *dd*	6.19 *dd*
H-7	2.92 *ddd* (*br*)	2.85 *s* (*br*)	2.88 *s* (*br*)
H-8	5.75 *d* (*br*)	5.18 *dd* (*br*)	5.19 *dd* (*br*)
H-9	2.83 *dd*	2.82 *dd*	2.85 *dd*
H-9′	1.30 *d* (*br*)	1.33 *d* (*br*)	1.35 *d* (*br*)
H-13	6.28 *d*	6.36 *d*	6.37 *d*
H-13′	5.57 *d*	5.77 *d*	5.78 *d*
H-14	1.15 *s*	1.48 *s*	1.43 *s*
H-15	1.90 *s* (*br*)	1.83 *d*	1.83 *d*
OTigl	6.83 *q* (*br*)	6.86 *q* (*br*)	6.89 *q* (*br*)
	1.83 *s* (*br*)	1.81 *s* (*br*)	1.83 *s* (*br*)
	1.83 *d* (*br*)	1.82 *d* (*br*)	1.80 *d* (*br*)
OAc	—	—	2.15 *s*

J (Hz): **3**: 1,2 = 2.5; 1,2′ = 11; 2,2′ = 14; 2,3 = 5; 2,3′ = 2.5; 2′,3 = 12; 2′,3′ = 2; 3,3′ = 13; 5,6 = 11; 6,7 = 9; 7,8 ~ 1; 7,13 = 3.5; 7,13′ = 3; 8,9 = 5; 9,9′ = 15; **5**: 1,2 = 3.5; 1,2′ = 10; 2,3 = 2′,3 ~ 3; 2,2′ = 15; 5,6 = 11; 5,15 = 1; 6,7 ~ 1; 7,8 ~ 1; 7,13 = 2; 8,9 = 4; 9,9′ = 15; OTigl: 3′,4′ = 7.

*Part 338 in the series "Naturally Occurring Terpene Derivatives". For Part 337 see Bohlmann, F., Zdero, C., Robinson, H. and King, R. M. (1981) *Phytochemistry* **20**, 1631.

Table 2. ^{1}H NMR data of compounds **6**–**8** (270 MHz, $CDCl_3$, TMS as internal standard)

	6	7	8
H-1	3.54 *dd* (*br*)	3.56 *dd* (*br*)	3.68 *dd* (*br*)
H-2	1.92 *m*	1.7 *m*	2.44 *m*
H-2′	1.64 *m*		
H-3	2.40 *d* (*br*)	2.4 *m*	5.37 *d* (*br*)
H-3′	2.14 *ddd* (*br*)	2.2 *m*	
H-5	2.28 *d* (*br*)	—	2.44 *m*
H-6	4.52 *dd*	5.13 *d* (*br*)	4.45 *dd*
H-7	2.87 *dddd*	2.94 *ddd*	2.80 *dddd*
H-8	5.82 *ddd*	5.82 *ddd*	5.81 *ddd*
H-9	2.40 *dd*	2.40 *dd*	2.37 *dd*
H-9′	1.64 *m*	1.63 *dd*	1.58 *dd*
H-13	6.17 *d*	6.22 *d*	6.15 *d*
H-13′	5.48 *d*	5.53 *d*	5.45 *d*
H-14	1.00 *s*	1.24 *s*	1.07 *s*
H-15	5.05 *s* (*br*)	1.90 *s* (*br*)	1.90 *s* (*br*)
H-15′	4.98 *s* (*br*)		
OTigl	6.84 *q* (*br*)	6.84 *q* (*br*)	6.83 *q* (*br*)
	1.82 *d* (*br*)	1.81 *d* (*br*)	1.81 *d* (*br*)
	1.83 *s* (*br*)	1.82 *s* (*br*)	1.82 *s* (*br*)

J (Hz): **6**: 1,2 = 4.5; 1,2′ = 11; 2,3 = 6; 2,3′ = 13; 2′,3 = 6; 3,3′ = 13; 5,6 = 11; 6,7 = 10; 7,8 = 2.5; 7,13 = 3.5; 7,13′ = 3; 8,9 = 8, 9′ = 2.5; 9,9′ = 15; **7**: 1,2 = 5; 1,2′ = 11; 6,7 = 11; 7,8 = 3; 7,13 = 3.5; 7,13′ = 3; 8,9 = 8, 9′ = 2.5; 9,9′ = 15; **8**: 1,2 = 6; 1,2′ = 9; 2,3 ~ 4; 5,6 = 6, 7 = 11; 7,8 ~ 3; 7,13 = 3.5; 7,13′ = 3; 8,9 = 2; 8,9′ = 3; 9,9′ = 15; OTigl: 3′, 4′ = 7.

Experimental) allowed the assignment of the positions of the keto group and the double bonds.

The roots afforded bisabolene, **1** and **2** only.

The type of compounds isolated showed that *C. rotundifolia* belongs to the group of *Calea* species which should be placed away from the Galinsoginae.

EXPERIMENTAL

The air-dried plant material (voucher RMK 8350) was extracted with Et_2O–petrol (1:2), and the resulting extracts were separated by column chromatography and repeated TLC (Si gel). Known compounds were identified by comparison with authentic material (IR, ^{1}H NMR). The roots (300 g) afforded 20 mg bisabolene, 20 mg **1** and 20 mg **2**, while the aerial parts (240 g) gave 20 mg germacrene D, 20 mg α-humulene, 10 mg bicyclogermacrene, 5 mg caryophyllene, 200 mg squalene, 20 mg **1**, 20 mg **2** and a mixture of **3**–**9**, which was separated by TLC using Et_2O–petrol (1:1) followed by several times with CH_2Cl_2–C_6H_6 (1:1). Finally, 2 mg **3**, 10 mg **4**, 4 mg **5**, 5 mg **6**, 1 mg **7**, 1 mg **8** and 1 mg **9** were obtained.

1β,10α-Epoxy-8β-tiglinoyloxy-1,10-dihydrocostunolide (**3**). Colourless gum, IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1775 (γ-lactone), 1715 (C=CCO$_2$R); MS *m/z* (rel. int.): 346.178 (M$^+$, 1) ($C_{20}H_{26}O_5$), 246 (M−RCO$_2$H, 7), 83 ($C_4H_7CO^+$, 100), 55 (83 − CO, 91);

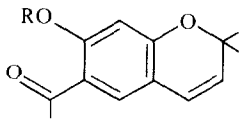
$$[\alpha]_{24°}^{\lambda} = \frac{589 \quad 578 \quad 546 \quad 436\,\text{nm}}{+70 \quad +75 \quad +82 \quad +148} \quad (c = 0.1,\ CHCl_3).$$

Heliangin-3-O-acetate (**5**). Colourless gum, IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1775 (γ-lactone), 1755 (OAc), 1725 (C=CCO$_2$R); MS *m/z* (rel. int.): 404.184 (M$^+$, 0.4) ($C_{22}H_{28}O_7$), 304 (M − RCO$_2$H, 2), 261 (304 − MeCO$^·$, 18), 244 (304 − HOAc, 6), 83 ($C_4H_7CO^+$, 100), 55 (83 − CO, 68);

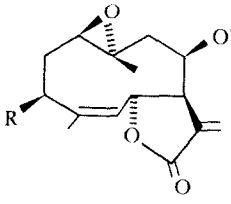
$$[\alpha]_{24°}^{\lambda} = \frac{589 \quad 578 \quad 546 \quad 436\,\text{nm}}{-21 \quad -23 \quad -25 \quad -43} \quad (c = 0.3,\ CHCl_3).$$

8β-Tiglinoyloxyreynosin (**6**). Colourless gum, IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3630 (OH), 1780 (γ-lactone), 1720, 1650 (C=CCO$_2$R); MS *m/z* (rel. int.): 346.178 (M$^+$, 1) ($C_{20}H_{26}O_5$), 246 (M − RCO$_2$H, 9), 228 (246 − H$_2$O, 14), 202 (246 − CO$_2$, 19), 83 ($C_4H_7CO^+$, 100), 55 (83 − CO, 68);

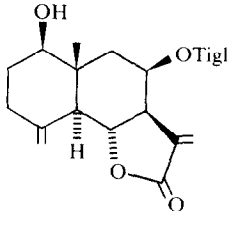
$$[\alpha]_{24°}^{\lambda} = \frac{589 \quad 578 \quad 546 \quad 436\,\text{nm}}{+16 \quad +18 \quad +20 \quad +34} \quad (c = 0.5,\ CHCl_3).$$



1 R = H
2 R = Me



3 R = H (4,5-*trans*)
4 R = OH
5 R = OAc



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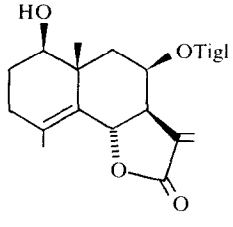

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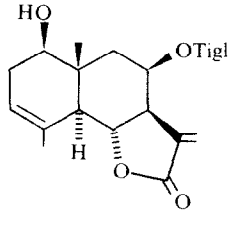

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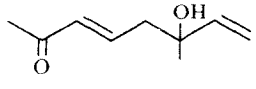

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1β-*Hydroxy*-8β-*tiglinoyloxyarbusculin B* (**7**). Colourless gum, IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3620 (OH), 1785 (γ-lactone), 1720 (C=CCO$_2$R); MS *m/z* (rel. int.): 346.178 (M$^+$, 2) ($C_{20}H_{26}O_5$), 246 (M − RCO$_2$H, 82), 228 (246 − H$_2$O, 14), 202 (246 − CO$_2$, 28), 83 ($C_4H_7CO^+$, 100), 55 (83 − CO, 98);

$$[\alpha]_{24°}^{\lambda} = \frac{589 \quad 578 \quad 546 \quad 436\,\text{nm}}{+10 \quad +12 \quad +15 \quad +23} \quad (c = 0.1,\ CHCl_3).$$

8β-*Tiglinoyloxybalchanin* (**8**). Colourless gum, IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3620 (OH), 1780 (γ-lactone), 1710 (C=CCO$_2$R); MS *m/z* (rel. int.): 346.178 (M$^+$, 5) ($C_{20}H_{26}O_5$), 246 (M − RCO$_2$H, 16), 228 (246 − H$_2$O, 6), 83 ($C_4H_7CO^+$, 100), 55 (83 − CO, 58);

$$[\alpha]_{24°}^{\lambda} = \frac{589 \quad 578 \quad 546 \quad 436\,\text{nm}}{+24 \quad +28 \quad +36 \quad +60} \quad (c = 0.1,\ CHCl_3).$$

3-*Hydroxy-octa*-1,5t-*dien*-7-*one* (**9**). Colourless oil, IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3600 (OH), 1730 (C=O); MS *m/z* (rel. int.): 154.099 (M$^+$, 6) ($C_9H_{14}O$), 136 (M − H$_2$O, 12), 71 (C_4H_7O, 100); CIMS (isobutane): 155 (M$^+$ 1, 48), 85 (C_5H_7O, 100); ^{1}H NMR ($CDCl_3$): δ 5.13 (*dd*, H-1c, *J* = 11, 1.5 Hz), 5.26 (*dd*, H-1t, *J* = 17, 1.5), 5.95 (*dd*; H-2, *J* = 17, 11), 2.46 (*d*, H-4, *J* = 8), 6.79 (*dt*, H-5, *J* = 15.5, 8), 6.11 (*d*, H-6, *J* = 15.5), 2.26 (*s*, H-8), 1.33 (*s*, H-9), 4.74 (*s*, OH).

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