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Melampolides from *Enydra anagallis*

Alicia Bardón [a], Luz Cardona [b], Elena Cartagena [a], César A.N. Catalán [a], José R. Pedro [b,*]

[a] *Instituto de Química Orgánica, Facultad de Bioquímica,Química y Farmacia, Universidad Nacional de Tucumán, Ayacucho 491, S.M. de Tucumán 4000, Argentina*

[b] *Departamento de Química Orgánica, Facultad de Química, Universitat de València, 46100-Burjassot Valencia, Spain*

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Abstract

The investigation of an Argentine collection of *Enydra anagallis* afforded sesquiterpene lactones of the melampolide type two of which were previously known. Their structures were elucidated by spectroscopic methods.

Keywords: *Enydra*; Compositae; Heliantheae; Sesquiterpene lactones; Melampolides

1. Introduction

The genus *Enydra* (Asteraceae, tribe Heliantheae) was placed by Stuessy (1977) in the subtribe Ecliptinae and then by Robinson (1981) in the subtribe Enhydrinae. Karis sampled many genera of Heliantheae in his morphological cladistic analysis and placed *Enydra* in the subtribe Melampodiinae (Bremer, 1994). It is one of the few genera of wet or aquatic habitats in the Compositae. The genus was originally described by Loureiro (1790) as *Enydra* but later it was spelled as "*Enhydra*" (De Candolle, 1836) taking in account the etymology of the word (from Greek, enhydra: in water).

From numerous species of *Tetragonotheca*, *Sigesbeckia*, *Acanthospermum*, *Melampodium*, *Lecocarpus*, and *Smallanthus*, all included in the subtribe Melampodiinae (Bremer, 1994), many diterpenoids and melampolide type sesquiterpenoids were isolated (Quijano et al., 1979; Barua et al., 1980; Saleh et al., 1980; Bohlmann et al., 1981, 1984a; Castro et al., 1989; Zdero et al., 1991; Macías and Fischer, 1992; Macías et al., 1993; Inoue et al., 1995; Quijano et al., 1997). Phytochemical studies of *E. fluctuans*, the only species of the genus previously investigated, have led to the isolation of several sesquiterpene lactones of melampolide type (Ali et al., 1972; Bohlmann et al., 1982a,b; Krishnaswamy and Ramh, 1995). *E. fluctuans* is used in Indian medicine in treatment of nervous ailments, skin diseases and has been employed as laxative (Chopra, 1956), anti-inflammatory, anti-bilious and demulcent (Kirtikar and Basu, 1933; Sastri, 1952).

From *E. anagallis*, the only species of this genus growing in Argentina, we now report the isolation of eight melampolides (**1**–**8**). Compounds **2**, **3** and **5**–**8** are described for the first time in this paper, and their structures were elucidated by extensive highfield NMR studies, standard ^{1}H–^{1}H COSY, HMQC and NOE experiments.

2. Results and discussion

Compound **1** was a gum with IR absorptions at 1760, 1735 and 1710 cm^{-1} which accounts for an α-methylene γ-lactone, a saturated ester and an α,β-unsaturated ester respectively. ^{1}H NMR data (Table 1) strongly suggested the presence of a 6,12-melampolide skeleton with two acyloxy side chains located at C-8 and C-9. An extensive NMR study, including ^{1}H, ^{13}C and NOE experiments, allowed us to assigne compound 1 the structure of uvedalin previously isolated from *Polymnia uvedalia* (Herz and Bhat, 1970) and *Smallanthus sonchifolius* (Inoue et al., 1995). Relative stereochemistry was supported by NOE experiments.

Compounds **2**–**5** showed ^{1}H and ^{13}C NMR data almost identical to those of the previously described for the 6,12-melampolide skeleton of compound **1**, even the signals for the C-14 methyl ester group and the C-9

* Corresponding author Tel.: +34-09-638-64329; fax: +34-09-638-64328.

E-mail address: jose.r.pedro@uv.es (J.R. Pedro).

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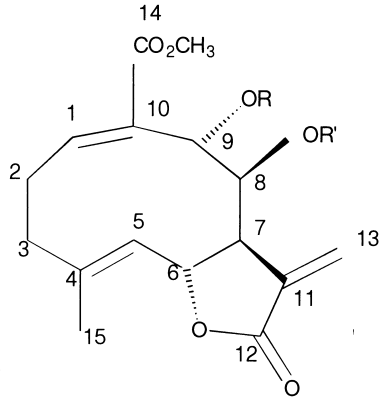

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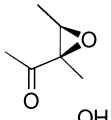
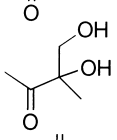
1	Ac	
2	Ac	
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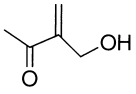
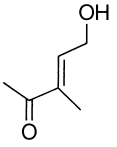
4	Ac	
5	Ac	
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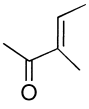
7	H	
8	H	H

acetate group. Close similarity in chemical shifts, coupling patterns and coupling constants led us to assume identical skeletal features for all of them. Differences were found in the side chains located at C-8. The ^{1}H NMR spectrum of **2** showed a three-proton singlet at δ 1.37 and a two proton AB system centered at δ 3.60 (J = 11.2 Hz), while the ^{13}C NMR spectrum displayed two signals at δ 56.9 (*s*) and δ 50.5 (*t*) for tetra- and disubstituted carbons bearing oxygen. The mentioned signals suggested a 2,3-dihydroxy-2-methylpropanoyloxy side chain at C-8 (Abegaz et al., 1994). This was further confirmed by diagnostic MS peaks. The MS spectrum showed the base peak at m/z 272 [M-HOAc-HOCOC(-CH_3)(OH)CH_2 (OH)]$^+$, a strong peak at m/z 213 (60%) due to the loss of 2,3-dihydroxy-2-methylpropionic acid, acetic acid and -(CO)OCH_3 group from the molecular ion and a small peak at m/z 240 related to the loss of 2,3-dihydroxy-2-methylpropionic acid, acetic acid and methanol from the molecular ion.

Compound **3** had a molecular formula $C_{22}H_{26}O_8$ (molecular ion peak at m/z 418.1630) and the ^{1}H NMR spectral parameters were nearly identical to those of the 6,12-melampolide **1**. ^{1}H NMR signals associated with the side chain were one vinyl proton broad singlet at δ 6.02, one vinyl proton triplet at δ 5.57 (J = 1.6 Hz) and a three- proton broad singlet at δ 1.93 (vinyl methyl protons). These values as well as the ^{13}C NMR signals at δ 126.6 (CH_2), δ 135.4 (C) and δ 16.9 (CH_3) suggested the presence of a methacrylate side chain (Rustaiyan et al., 1991; Abegaz et al., 1994). The structure of compound **3** was further supported by the mass spectral pattern with peaks at m/z 272 [(M-HOAc–HOCOC(CH_3)=CH_2)]$^+$, m/z 213 due to the loss of methacrylic acid, acid acetic and -(CO)OCH_3 from the molecular ion and m/z 240 due to the loss of methacrylic acid, acetic acid and methanol from the molecular ion as well as by a base peak at m/z 69 [C_4H_5O]$^+$ (Walachy and Fischer, 1981).

Compound **4**, $C_{22}H_{26}O_9$ (molecular peak at m/z 434.1576) showed ^{1}H NMR spectral data nearly identical to those of compound **3** being the signals of the side chain the most noticeable difference. These ^{1}H NMR data, including coupling constants, were in good agreement with the compound named 19-hydroxy-15-desoxy-orientalide previously isolated from *Clibadium pittierii* (Tamayo-Castillo et al., 1988).

The mass spectrum of compound **5** showed the [M]$^+$ at m/z 448.1739 which agreed with the molecular formula $C_{23}H_{28}O_9$. The features of the ^{1}H and ^{13}C NMR spectra suggested, as in the previously described compounds a 6,12-melampolide skeleton bearing methyl ester at C-14 and an acetate group at C-9. The main differences were observed in the signals of the side chain located at C-8. The ^{1}H NMR spectrum showed a three- proton doublet at δ 1.79 (J=1.2 Hz); a two-proton doublet at δ 4.34 (J= 5.6 Hz) and a one-proton triple doublet at δ 6.79 (J=6.0 and 1.6 Hz). Both doublets at δ 1.79 and 4.34 collapsed into singlets when the signal at δ 6.79 was irradiated. The ^{13}C NMR spectrum exhibited signals for two olefinic carbons at δ 127.6 (*d*) and δ 141.6 (*s*) and a methylene group at δ 59.7 (*t*) linked to oxygen, probably a hydroxyl group (IR absorption at 3473 cm^{-1}). This results, together with the presence of peaks at m/z 272 [M-HOAc–HOCO–C(CH_3)=CH–CH_2OH]$^+$, 99 [C_5H_7 O_2]$^+$ and 71 [C_4H_7 O]$^+$ in the mass spectrum led us to the conclusion that the side chain group must be 4-hydroxy-3-methyl-2-butenoyl (Bohlmann et al., 1982a, 1984b; El-Masry et al., 1985; Hernández et al., 1994), 4-hydroxy-2-methyl-3-butenoyl

(Bohlmann et al., 1982b; Öksuz and Ayyildiz, 1986) or 2-hydroxymethyl-2-butenoyl (Herz et al., 1984; El-Masry et al., 1985; Rustaiyan et al., 1991). The stereochemistry of the side chain double bond was deduced by NOE experiments. Saturation of the H-4′ signal led to an increment in intensity of the H-5′ and H-3′ signals, however, saturating the H-3′ signal only caused an increment of the H-4′signal intensity. Therefore the side chain in 5 must be a 4′-hydroxytiglate and not a 4′-hydroxyangelate.

The ^{1}H NMR spectra of compounds **6** and **7** showed the spectral pattern observed in compounds described above (Tables 1 and 2). However, the signal corresponding to the C-9 acetate group was not present. Instead, a higher field signal assigned to H-9 was observed suggesting a hydroxyl group situated at this position. In compound **6** this signal appeared at δ 4.00 as a triplet ($J=10$ Hz) coupling with H-8 (δ 6.27) and with the signal at δ 2.75 which was assigned to the proton of hydroxyl group. The signals corresponding to the acyloxy side chain located at C-8 were very similar to that compound **3** (Tables 1 and 2) so compound **6** was the 9-deacyl-derivative of compound **3**. The exact mass measurement of the $[M]^+$ at m/z 376.1522, provides the molecular formula $C_{20}H_{24}O_7$ and confirms this assignment.

In compound **7** the H-9 signal at δ 4.00 (*t*, *J ca* 9.0 Hz) and a signal at δ 2.80 (*d*, $J=9.6$ Hz) ascribable to the hydroxyl proton suggested again the structure of a 9-deacyl derivative. The nature of the acyloxy side chain at C-8 was evident from the ^{1}H NMR data: a one-proton multiplet overlapped with the H-1 signal at δ 6.84, and two three-proton signals, a broad singlet at δ 1.83 and a broad doublet at δ 1.80 ($J=7.2$ Hz) typical of a tiglic ester moiety (Lazari et al., 1998; Spring et al., 1999). Tiglate was clear also by the signals at δ 166.9 (C), 127.8 (C), 138.8 (CH), 14.5 and 12.8 (two CH_3) in the ^{13}C NMR spectrum. The side chain double bond configuration was confirmed by NOE experiments. The exact mass measurement of the $[M]^+$ at m/z 390.1675 provides a molecular formula $C_{21}H_{26}O_7$ and the mass peaks at m/z 290 $[M\text{-}HOCO\text{–}C(CH_3)=CH(CH_3)]^+$ and m/z 83 confirmed the nature of the ester side chain.

The ^{1}H NMR spectrum of compound **8** showed all the signals corresponding to a 6,12-melampolide skeleton. However two characteristics in the spectrum of compound **8** with respect to all other compounds previously described were obvious: absence of signals due to the lack of any side chain and a dramatic highfield shift of the signal for H-8 from *ca* δ 6.30 to δ 4.69. The molecular peak of compound **8** at m/z 309.1354 $[M+H]^+$ indicative for a molecular formula $C_{16}H_{20}O_6$, together with a large OH band in the IR spectrum at 3425 cm^{-1} and the sixteen peaks present in the ^{13}C NMR spectrum allow us to propose the structure of compound **8**.

3. Experimental

3.1. General

NMR: 400 MHz (^{1}H) and 75.4 MHz (^{13}C) in $CDCl_3$. NOE measurements were carried out by the one-dimensional difference method. Optical rotations at 20°. Low

Table 1
^{1}H NMR chemical shifts of compounds **1–4** (400 MHz, $CDCl_3$, δ values)

H	1	2	3	4
1	7.00 *dd* (10.4, 7.6)[d]	7.01 *dd* (10.0, 7.2)	7.00 *dd* (10.0, 7.2)	7.01 *dd* (10.0, 7.6)
2a	2.66 *dddd* (12.8, 12.8, 10.8, 2.0)	2.64 *dddd* (12.8, 12.8, 10.4, 2.0)	2.65 *dddd* (12.4, 12.4, 10.4, 2.0)	2.62 *dddd* (12.8, 12.8, 10.8, 2.0)
2b	2.46 *dddd* (12.4, 7.6, 5.6, 1.6)	2.45 *dddd* (12.4, 8.0, 6.0, 2.0)	2.44 *dddd* (12.0, 8.0, 6.0, 2.0)	2.45 *dddd* (12.4, 8.0, 6.0, 2.0)
3a	2.39 *ddd* (12.4, 5.6, 2.0)	2.39 *ddd* (12.0, 6.0, 2.0)	2.39 *ddd* (12.0, 6.0, 2.0)	2.38 *ddd* (13.0, 6.0, 2.0)
3b	2.03 *brt* (*ca* 11.6)	2.03 *brt* (*ca* 12.0)	2.03 *brt* (*ca* 11.6)	2.04 *brt* (*ca* 11.8)
5	4.95 *brd* (10.8)	4.95 *brd* (10.8)	4.96 *brd* (10.4)	4.96 *brd* (11.2)
6	5.10 *t* (10.4)	5.08 *t* (10.0)	5.11 *t* (10.0)	5.12 *t* (10.0)
7	2.78 *dddd* (9.6, 3.2, 3.2, 1.2)	2.78 *dddd* (9.6, 3.2, 3.2, 1.2)	2.76 *dddd* (10.0, 3.2, 2.8, 1.2)	2.78 *dddd* (9.6, 3.6, 3.6, 1.2)
8	6.65 *dd* (8.4, 1.2)	6.64 *dd* (8.4, 1.2)	6.62 *dd* (8.8, 1.4)	6.64 *dd* (8.4, 1.4)
9	5.40 *d* (8.4)	5.41 *d* (8.4)	5.43 *d* (8.4)	5.46 *d* (8.4)
13a	6.25 *d* (3.2)	6.29 *d* (3.6)	6.26 *d* (3.2)	6.27 *d* (3.6)
13b	5.72 *d* (2.8)	5.77 *d* (2.8)	5.81 *d* (3.2)	5.80 *d* (3.2)
15[a]	1.99 *s*	1.99 *s*[c]	1.89 *s*[c]	1.94 *s*[c]
-OCH_3	3.80 *s*	3.80 *s*	3.79 *s*	3.80 *s*
-OAc	1.99 *s*	1.98 *s*[c]	2.03 *s*[c]	2.02 *s*[c]
-OH				
3′a	3.01 *q* (5.2)	3.67 *d* (11.2)	6.02 *brs*	6.17 *brs*
3′b		3.52 *d* (11.2)	5.57 *t* (1.6)	5.86 *d* (1.2)
4′	1.18 *d* (5.2)[a]	1.37 *s*[a]	1.93 *s*[a]	4.28 *brs*[b]
5′[a]	1.46 *s*			

[a] Three proton intensity.
[b] Two proton intensity.
[c] Assignments may be interchanged.
[d] Figures in parentheses are coupling constants in Hertz.

Table 2
^{1}H NMR chemical shifts of compounds **5–8** (400 MHz, $CDCl_3$, δ values)

H	5	6	7	8
1	7.00 *dd* (10.4, 7.6)[e]	6.84 *dd* (10.4, 7.2)	6.84 *dd* (10.0, 7.6)[d]	6.80 *dd* (10.4, 7.6)
2a	2.64 *dddd* (12.4, 12.4, 10.8, 2.0)	2.48 *dddd* (12.8, 7.2, 6.0, 2.0)	2.48 *dddd* (12.4, 7.2, 6.0, 2.0)	2.45 *m*
2b	2.45 *dddd* (12.4, 8.0, 6.0, 2.0)	2.24 *dddd* (12.8, 12.8, 10.4, 2.0)	2.24 *dddd* (12.4, 12.8, 10.8, 2.0)	2.22 *dddd* (12.4, 12.8, 12.8, 2.0)
3a	2.38 *ddd* (12.0, 5.6, 2.0)	2.35 *ddd* (12.0, 6.0, 2.0)	2.35 *ddd* (12.0, 6.0, 2.0)	2.33 *ddd* (12.0, 6.0, 2.0)
3b	2.03 *brt* (ca 11.8)	2.03 *ddd* (12.0, 12.0, 2.0)	2.03 *ddd* (12.8, 12.0, 2.0)	2.01 *ddd* (12.8, 12.8, 2.0)
5	4.96 *brd* (10.4)	4.94 *brd* (10.8)	4.95 *brd* (9.6)	4.90 *brd* (10.4)
6	5.12 *t* (10.0)	5.09 *t* (10.0)	5.10 *t* (10.0)	5.17 *t* (10.0)
7	2.78 *dddd* (9.6, 3.2, 3.2, 1.2)	2.64 *dddd* (9.6, 3.2, 3.2, 1.6)	2.64 *dddd* (9.6, 3.2, 2.8, 1.6)	2.45 *m*
8	6.64 *dd* (8.4, 1.4)	6.27*dd* (8.4, 1.6)	6.28 *dd* (8.0, 1.6)	4.69 *dd* (8.0, 1.4)
9	5.43 *d* (8.4)	4.00 *t* (*ca* 9.0)	4.00 *t* (*ca* 9.0)	3.82 *m*
13a	6.25 *d* (3.6)	6.23 *d* (3.2)	6.22 *d* (3.2)	6.31 *d* (3.6)
13b	5.79 *d* (2.8)	5.66 *d* (3.2)	5.66 *d* (3.2)	5.57 *d* (3.2)
15[a]	1.93 *s*[c]	1.89 *s*[c]	1.90 *brs*	1.85 *s*
-OCH_3	3.80 *s*	3.80 *s*	3.80 *s*	3.77 *s*
-OAc	2.01 *s*[c]			
-OH		2.75 *d* (10.0)	2.80 *d* (9.6)	
3′a	6.74 *td* (6.0, 1.6)	6.09 *brs*	6.84 [d]	
3′b		5.61 *t* (1.6)		
4′	4.34 *d* (5.6)[b]	1.94 *s* [a,c]	1.80 *d* (7.2)[a]	
5′[a]	1.79 *d* (1.2)		1.83 *brs*	

[a] Three proton intensity.
[b] Two proton intensity.
[c] Assignments may be interchanged.
[d] Signals overlapped.
[e] Figures in parentheses are coupling constants in Hertz.

and high-resolution MS measured with a Fisons Instruments VG Autospec, GC 8000 (70 eV). For separation of mixtures Waters and Konik equipments were used. Columns: (A) Beckman Ultrasphere C 8 (5 μm, 10 mm i.d.×250 mm) and (B) Phenomenex Ultemex C 18 (5 μm, 10 mm i.d.×250 mm). Retention times were measured from the solvent peak.

3.2. Plant material

Aerial parts and roots of *Enydra anagallis* Gadner were collected at the flowering stage in December 1993 in wet places of the riverside of Rio Romano, Monteros, Tucumán province, Argentine (a voucher specimen, LIL No 595793 is deposited in the herbarium de la Fundación Miguel Lillo, Tucumán, Argentina).

3.3. Extraction and isolation

Flowers, leaves and roots (350 g) were extracted with $CHCl_3$ (2×3 l) at rt for 4 days with shaking to give 11.5 g of residue (yield 3.2%) which was suspended in 100 ml of EtOH at 55°C, diluted with 75 ml of H_2O and extracted successively with hexane (2×150 ml) and $CHCl_3$ (2×150 ml). The second $CHCl_3$ extract was evapd under red. pres. to give 1.9 g of residue which was chromatographed on Si gel (57 g, 70–230 Mesh) with $CHCl_3$ and increasing amounts of EtOAc (0–100%) and finally MeOH; 82 fractions of 10 ml each being collected. Fractions containing sesquiterpene lactones (IR band at 1765 cm^{-1}) were further purified. Frs. 1-14 (383 mg) were eluted with $CHCl_3$ and increasing amounts of EtOAc (0–5%) and combined (383 mg). They were defatted with MeOH and, after filtration and evapn of solvent, the residue was processed by HPLC (Column B, MeOH–H_2O 2:1, 2 ml min^{-1}) to give compounds **6** (40 mg, R_t 6 min), **1** (78 mg, R_t 10 min) and **3** (52 mg, R_t 17 min). Frs. 15-29 (eluted with $CHCl_3$-EtOAc 95:5) were combined (509 mg) and processed by HPLC (Column B, MeOH–H_2O 4:3, 1.5 ml min^{-1}) to give four fractions which showed to be mixtures by TLC analysis. Rechromatography by HPLC (Column A, MeOH–H_2O 1:1, 1.7 ml min^{-1}) afforded compounds **6** (93 mg, R_t 19 min), **7** (8 mg, R_t 29 min) and **1** (5 mg, R_t 31 min). Fr 30-51 eluted with a $CHCl_3$-EtOAc gradient (9:1→8:2) and combined (375 mg). A portion (200 mg) was processed by HPLC (Column B, MeOH–H_2O 4:3,1.3 ml min^{-1}) to give compound **2** (22 mg, R_t 30 min). Frs 52-65 eluted with a $CHCl_3$–EtOAc gradient (3:1→1:2) and combined (183 mg). HPLC (Column B, MeOH–H_2O 6:5, 1.5 ml min^{-1}) gave compound **4** (37 mg, R_t 21 min) and a mixture (R_t 22-23 min) which was further processed by HPLC (Column A, MeOH–H_2O 6:5, 2 ml min^{-1}) to give a new portion of **4** (3 mg, R_t 22 min) and **5** (3 mg, R_t 27 min). Frs 66-82 were eluted with EtOAc and finally MeOH. They were combined (280 mg) and chromatographed by HPLC (Column B, MeOH–H_2O 1:1, 1.2 ml min^{-1}) to give compound **8** (46.8 mg, R_t 8 min).

*3.3.1. Compound **1***

Oil; $[\alpha]_D^{20}$ +20.9° ($CHCl_3$, *c* 0.004); UV λ_{max}(MeOH) nm: 219; IR ν_{max}(film) cm^{-1}: 1760, 1735, 1710; ^1H NMR and ^{13}C NMR: Tables 1 and 3; HREIMS (70 eV) *m/z* (rel. int.): 272.1064 $[M–R'OH–AcOH]^+$ (calc. for $C_{16}H_{16}O_4$ 272.1048), 240 (27), 213 (57), 71 (8).

*3.3.2. Compound **2***

Oil; $[\alpha]_D^{20}$ −13.6° ($CHCl_3$, *c* 0.006); IR ν_{max}(film) cm^{-1}: 3473, 1767, 1746, 1714; ^1H NMR and ^{13}C NMR: Tables 1 and 3; HREIMS (70 eV) *m/z* (rel. int.): 333.1345 $[M-R'O]^+$ (4.7) (calc. for $C_{18}H_{21}O_6$ 333.1338), 272 (100), 258 (21), 213 (60), 128 (13), 91 (26).

*3.3.3. Compound **3***

Oil; $[\alpha]_D^{20}$ +54.2° ($CHCl_3$, *c* 0.012); IR ν_{max} (film) cm^{-1}: 1765, 1730, 1715; ^1H NMR and ^{13}C NMR: Tables 1 and 3; HREIMS (70 eV) *m/z* (rel. int.): 418.1630 $[M]^+$ (2.1) (calc. for $C_{22}H_{26}O_8$ 418.1628), 272 (77), 240 (16), 213 (35), 69 (100).

*3.3.4. Compound **4***

Oil; $[\alpha]_D^{20}$ +50.7° ($CHCl_3$, *c* 0.002); UV λ_{max} (MeOH) nm: 218; IR ν_{max} (film) cm^{-1}: 3400, 1760, 1730, 1630; ^1H NMR and ^{13}C NMR: Tables 1 and 3; HREIMS (70 eV) *m/z* (rel. int.): 434.1576 $[M]^+$ (1) (calc. for $C_{22}H_{26}O_9$ 434.1577), 374 (8.9), 272 (100), 240 (15), 213 (53), 85 (53).

*3.3.5. Compound **5***

Oil; $[\alpha]_D^{20}$ +63.7° ($CHCl_3$, *c* 0.003); UV λ_{max} (MeOH) nm: 210; IR ν_{max} (film) cm^{-1}: 3473, 1767, 1738; ^1H NMR and ^{13}C NMR: Tables 2 and 3; HREIMS (70 eV) *m/z* (rel. int.): 448.1739 $[M]^+$ (2.6) (calc. for $C_{23}H_{28}O_9$ 448.1733), 350 (2.8), 272 (84), 240 (14), 213 (33), 99 (100), 71 (41).

*3.3.6. Compound **6***

Oil; $[\alpha]_D^{20}$ +60.5° ($CHCl_3$, *c* 0.013); UV λ_{max} (MeOH) nm: 221; IR ν_{max} (film) cm^{-1}: 3450, 1760, 1715, 1630; ^1H NMR and ^{13}C NMR: Tables 2 and 3; HREIMS (70 eV) *m/z* (rel. int.): 376.1522 $[M]^+$ (0.3) (calc. for $C_{20}H_{24}O_7$ 376.1522), 290 (9), 258 (22), 230 (10), 212 (16), 162 (15), 128 (9), 91 (9), 69 (100).

*3.3.7. Compound **7***

Oil; $[\alpha]_D^{20}$ +70.4° ($CHCl_3$, *c* 0.006); IR ν_{max} (film) cm^{-1}: 3465, 1765, 1714; ^1H NMR and ^{13}C NMR: Tables 2 and 3. HREIMS (70 eV) *m/z* (rel. int.): 390.1675 $[M]^+$ (0.5) (calc. for $C_{21}H_{26}O_7$ 390.1678), 359 (7), 290 (15), 258 (25), 240 (11), 2122 (13), 162 (12), 128 (5.8), 83 (100).

*3.3.8. Compound **8***

Oil; $[\alpha]_D^{20}$ −22.7° ($CHCl_3$, *c* 0.007); IR ν_{max} (film) cm^{-1}: 3452, 1761,1710; ^1H NMR and ^{13}C NMR: Tables 2 and 3; HRCIMS *m/z* (rel. int.): 309.1354 $[M+H]^+$ (36) (calc.

Table 3
^{13}C NMR chemical shifts of compounds **1**–**8** (75 MHz, $CDCl_3$, δ values)[b]

C	**1**[a]	**2**[a]	**3**[a]	**4**[a]	**5**[a]	**6**[a]	**7**[a]	**8**[a]
1	148.4	148.4	148.3	148.4	148.3	144.4	144.3	144.5
2	26.1	26.1	26.1	26.1	26.1	25.8	25.8	25.9
3	36.9	36.9	36.9	36.9	36.9	36.8	36.8	36.8
4	130.6	130.5	130.6	130.6	130.6	133.8	133.9	133.5
5	126.2	126.4	126.3	126.2	126.2	126.5	126.6	126.9
6	76.9	74.9	75.3	75.2	75.3	75.5	75.6	74.8
7	50.9	50.8	50.9	50.9	51.0	51.6	51.6	51.6
8	70.9	72.3	70.2	70.4	70.2	72.8	72.4	71.6
9	75.2	70.8	71.1	70.9	71.1	71.3	71.4	72.8
10	134.4	133.6	134.3c	134.2	134.3	134.7c	134.7	136.0
11	138.6	138.6	138.5	138.5b	138.5	137.6	137.6	137.6
12	169.1a	170.2a	170.2a	170.4a	170.2a	169.3a	169.4a	169.9a
13	121.5	122.1	121.8	119.9	121.8	121.3	121.3	120.1
14	168.4a	169.0a	170.2a	169.2a	169.4a	167.0a	167.8a	167.6a
15	16.9b	16.8b	16.9b	16.9	16.9	16.9b	16.9	
-OCH_3	53.3	52.3	52.3	52.1	52.3	52.3	52.3	52.1
-OAc	165.9	165.8	165.9	165.9	165.9			
	20.9	20.9	20.8	20.8	20.8			
1′	170.2a	172.7a	165.9a	164.9a	166.1a	166.9a	166.9a	
2′	59.3	56.9	135.4c	138.8b	127.6	135.5c	127.8	
3′	59.9	50.5	126.6	126.9	141.6	126.6	138.8	
4′	13.6	23.6	18.3b	62.3	59.7	18.3b	14.5	
5′	19.1b				12.8		12.2	

[a] Assignments a,b,c may be interchanged within each column.
[b] Signals of all compounds have been assigned by means of 2D NMR experiments.

for $C_{16}H_{21}O_6$ 306.1338), 291 (43), 273 (37), 259 (100), 241 (51), 231 (37), 213 (26), 128 (31).

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