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HIGHLY OXYGENATED SESQUITERPENES FROM THE SUBTRIBE NASSAUVIINAE

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Key Word Index—*Oxyphyllum ulicinum*; *Polyachyrus fuscus*; Compositae; sesquiterpenes; sesquiterpene acids; highly oxygenated germacrane derivatives; eudesmane derivatives; nerolidol glycoside.

Abstract—The aerial parts of *Oxyphyllum ulicinum* afforded, in addition to known compounds, 15 new germacrane derivatives with a 1β, 10α-epoxide, a carboxyl group at C-4, and different ester groups at C-9 and C-14. From the aerial parts of *Polyachyrus fuscus*, five highly oxygenated eudesmanes and a nerolidol glycoside were isolated. The structures were elucidated by high field NMR techniques.

INTRODUCTION

The monotypic genus *Oxyphyllum* (Compositae, tribe Mutisieae) is placed in the subtribe Nassauviinae. The genus *Polyachyrus*, with seven species distributed on the west slopes of the Andes from Peru to Central Chile [1] belongs to the same subtribe. We have studied *Oxyphyllum ulicinum* Phil. and *Polyachyrus fuscus* Meyen et Walp. in order to explore chemical relationships to other genera of the subtribe. The results are discussed in this paper.

RESULTS AND DISCUSSION

The extract of the aerial parts of *Oxyphyllum ulicinum* afforded lup-20-en-3β,16β-diol [2], lupenone, caffeic acid and the germacrane derivatives **1**–**15**. The ^{1}H NMR spectra (Tables 1 and 2) clearly pointed to two groups of very similar compounds. The structure of **2** followed from the molecular formula ($C_{22}H_{32}O_7$) and the ^{1}HNMR spectrum (Table 1), in which all signals could be assigned by spin decoupling. The low field broadened double doublet at δ 5.97 was due to an olefinic proton in the β-position to a carbonyl group. Irradiation of this signal sharpened the broadened doublet at δ 2.39 and changed the signal at δ 3.15. These two signals were also altered by irradiation of an overlapped multiplet at δ 2.26. The latter could be assigned to H-7 as its irradiation sharpened two exomethylene signals (H-13). Thus the carbomethoxy group was located at C-4. Starting with H-7 the signal of H-8 and H-9 (δ 4.48 *br d*) could be assigned.

Table 1. ^{1}H NMR spectral data of compounds **1**–**12** (400 MHz, $CDCl_3$, δ-values)

H	**2***	Compound	H-9	H-14	H-14′	OCOR
1	2.92 *dd*	**1**†	4.48 *dd*	4.45 *d*	3.88 *d*	2.42 *tq*, 0.90 *t*, 1.16 *d*
2α	2.16 *dddd*	**2**†	4.48 *dd*	4.46 *d*	3.86 *d*	2.59 *qq*, 1.18 *d*, 1.19 *d*
2β	1.61 *dddd*	**3**†	4.47 *dd*	4.43 *d*	3.95 *d*	2.33 *t*, 1.67 *tq*, 0.96 *t*
3α	2.26 *m*	**4**†	4.47 *dd*	4.43 *d*	3.97 *d*	2.38 *q*, 1.16 *t*
3β	2.75 *br d*	**5**†	4.46 *dd*	4.35 *d*	4.09 *d*	5.73 *br s*, 2.20 *d*, 1.92 *d*
5	5.97 *dd*	**6**	4.52 *dd*	4.46 *d*	3.88 *d*	2.43 *tq*, 0.91 *t*, 1.16 *d*; 5.65 *br s*, 2.14 *d*, 1.86 *d*
6α	2.39 *br d*	**7**	4.53 *dd*	4.44 *d*	3.92 *d*	2.61 *qq*, 1.19 *d*, 1.20 *d*; 5.66 *br s*, 2.15 *d*, 1.88 *d*
6β	3.15 *br q*	**8**	4.53 *dd*	4.42 *d*	3.99 *d*	2.34 *t*, 1.69 *tq*, 0.97 *t*, 5.66 *br s*, 2.15 *d*, 1.88 *d*
7	2.26 *m*	**9**	4.51 *dd*	4.51 *d*	4.11 *d*	5.73, 5.63 *br s*, 2.19, 2.14 *d*, 1.92, 1.86 *d*
8α	1.68 *br d*	**10**	3.26 *br d*	4.52 *d*	3.84 *d*	2.40 *tq*, 0.91 *t*, 1.14 *d*
8β	1.98 *ddd*	**12**	4.55 *dd*	4.44 *d*	3.85 *d*	2.43, 2.37 *tq*, 0.89 *t*, 1.14, 1.13 *d*
12	1.73 *br s*					
13	4.73 *br s*					
13′	4.67 *dq*					
OMe	3.80 s					

* Shift differences in the spectra of **1**, **3**–**5** and **12** ± 0.01; †OAc: 2.05 *s*. Compound **11**: H-7 2.01 *br t*; H-8α 1.38 *m*, H-8β 1.79 *br dd*, H-9α 2.59 *br dd*, H-9β 0.96 *br dd*, H-14 4.32 *d*, H-14′ 3.62 *d*; OMeBu: 2.44 *tq*, 1.66 *ddq* 1.49 *ddq*, 0.90 *t*, 1.13 *d*.

J[Hz]: 1,2α = 2.5; 1,2β = 11; 2α, 2β = 13; 2α,3α = 2α, 3β = 2; 2β,3α = 12; 2β,3β = 5; 3α,3β = 13.5; 5,6α = 4; 5, 6β = 11; 6α,6β = 14; 6β,7 = 12; 7,8β = 12; 8α,8β = 14; 8α,9 = 1; 8β, 9 = 9; 12, 13′ = 13,13′ = 1; 14,14′ = 12; OMeBu: 2,3 = 2, 5 = 3,4 = 3,5 = 7; OiBu: 2,3 = 2,4 = 7; OnBu: 2,3 = 3,4 = 7; OProp: 2,3 = 7; OSen: 2,4 = 2,5 = 1.

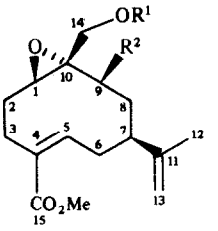
Table 2. ^{1}H NMR spectral data of **13–16** (400 MHz, C_6D_6, δ-values)

H	**13** (77°)	**14** (77°)	**15** ($CDCl_3$)	**16**†
1	2.79 *dd*	2.75 *dd*	2.11 *dd*	2.49 *d*
2	2.19 *m*	2.19 *m*	*	2.16 *m*
2′	1.63 *dddd*	1.63 *dddd*	*	1.33 *m*
5	6.98 *br dd*	6.98 *br dd*	6.88 *dd*	5.21 *dd*
6	2.09 *m*	2.09 *m*	*	5.45 *dd*
6′	1.80 *dd*	1.80 *dd*	*	
7	2.55 *br ddd*	2.55 *m*	*	2.57 *br t*
9	4.57 *dd*	4.57 *dd*	4.44 *dd*	4.72 *dd*
12	1.60 *br s*	1.60 *br s*	1.58 *br s*	1.64 *br s*
13	4.77 *br s*	4.77 *br s*	4.81 *br s*	4.79 *br s*
13′	4.73 *br s*	4.73 *br s*		4.76 *br s*
14	4.65 *br d*	4.67 *brd*	4.77 *m*	4.55 *d*
14′	4.55 *br d*	4.55 *br d*		4.49 *d*
OMe	3.56 *s*	3.54 *s*	3.77 *s*	3.31 *s*
OAc	1.76 *s*	1.73 *s*	—	1.75 *s*
OCOR	2.37 *tq*	2.47 *qq*	2.45 *tq*	2.38 *tq*
	0.90 *t*	1.14 *d*	5.68 *br s*	0.90 *t*
	1.15 *d*		0.94 *t*	1.15 *d*
			2.15 *br s*	
			1.20 *d*	
			1.89 *br s*	

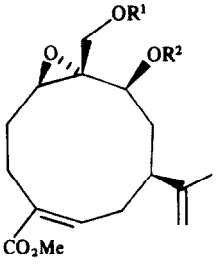
*Obscured signals; †H-4 2.81 *ddd*.

J [Hz]: Compounds **13–15:** 1,2 = 4; 1,2′ = 5,6 = 10; 5,6′ = 8; 6,7 = 4; 6′,7 = 7,8 = 8,9 = 11; 8′,9 = 2.5; 14,14′ = 11; compound **16**: 1,2 = 9; 3,4 = 12; 3′,4 = 2.5; 4,5 = 10; 5,6 = 15; 6,7 = 10; 7,8 = 12; 8,9 = 9; 8′,9 = 2.5; 14,14′ = 12; OMeBu: 2,3 = 2,5 = 3,4 = 7; OiBu: 2,3 = 2,4 = 7.

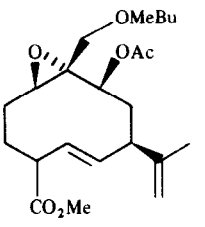
Irradiation of this signal sharpened a doublet at δ 3.88 which was geminal coupled with a doublet at δ 4.45. Accordingly, these signals were due to hydrogens on C-14, to which an oxygen function had to be attached. A double doublet at δ 2.92 was due to an epoxide proton. Starting with this signal the sequences H-1 to H-3 could be determined. These results eliminated the possibility of the presence of a 15-acyloxy derivative with a carbomethoxy group at C-10. The stereochemistry and the conformation was determined by NOE experiemnts, in particular by irradiation of H-7: clear effects with H-1, H-5, H-9 and H-13, required the usual conformation of germacrane derivatives with C-14 and C-15 above the plane. Furthermore, the configurations at C-1, C-7, C-9 and C-10 were settled. The relative position of the acyloxy groups was deduced from the observed chemical shift of H-9, which was identical in compounds **1–5**, while the shift of H-14 was influenced by the different ester groups. Furthermore, in the mass spectrum of **2** a fragment at *m/z* 247 was most likely due to elimination of $CH_2OCOC_3H_7$ from *m/z* 348, which in turn was formed by loss of acetic acid. Analogous fragments were also present in the mass spectrum of the other compounds. The assignement was further supported by partial saponification of **1**, which afforded the alcohol **10**. Finally, acetylation of compound **10** afforded the acetate **1**. These results allowed the assignment of the relative position of the ester groups in all the epoxides. The nature of the different ester groups could be deduced from the characteristic ^{1}H NMR signals. The ^{1}H NMR spectrum of **10** indicated a free hydroxy group at C-9 while that of **11** showed that no oxygen function was present at C-9. The parent compound, with no functional group at C-9 and a free hydroxyl group at C-14, has been named oxyphyllic acid.



	1*	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
R¹	MeBu	*i*Bu	*n*Bu	Prop	Sen	MeBu	*i*Bu	*n*Bu	Sen	MeBu	MeBu	MeBu
R²	OAc	OAc	OAc	OAc	OAc	OSen	OSen	OSen	OSen	OH	H	OMeBu



	13	**14**	**15**
R¹	MeBu	*i*Bu	MeBu
R²	Ac	Ac	Sen



16

*1–15 are the methylesters of the natural occuring acids

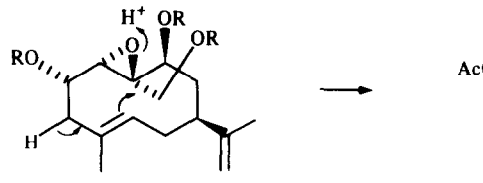
The ^{1}H NMR spectra of **13–15** (Table 2) were much less clear. At room temperature broadened signals were observed and even at elevated temperature only a partial assignment of the signals by spin decoupling was possible. The downfield shift of the H-5 signal required an *E*-configuration for the Δ^4-bond which was presumably the reason for a more flexible system. Although from biogenetic considerations the same configurations of the chiral centres as in the *Z*-isomers was likely, a final proof was desirable. Treatment of **1** with diazabicycloundecene (DBU) afforded nearly equal parts of the epoxides **13** and **16**. All data of the former were identical with those of the natural product while those of compound **16** showed that the Δ^4-bond was isomerized. The presence of a 5*E*-double bond and the configuration at C-4 followed from the observed ^{1}H NMR couplings. Thus, protonation of the corresponding anion is most likely thermodynamically controlled.

The aerial parts of *Polyachyrus fuscus* afforded the eudesmane derivatives **18–22** and the glycoside **23**, which was purified as its triacetate **23a.**

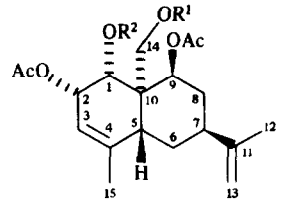
The structure of **18** was established by using different NMR techniques. The ^{1}H NMR spectrum (Table 3) indicated the presence of one tiglate and two acetate groups, but only in deuteriobenzene could all signals be assigned by spin decoupling. The resulting sequences required an eudesmane skeleton with 3,4- and a 11,13-double bonds, and oxygen functions at C-1, C-2, C-9 and C-14. The chemical shift of the signals of H-14 required a hydrogen bonded 14-hydroxy group, as followed from the large H-OH coupling and a *W*-coupling of one of the protons with H-1. The couplings of H-7 and H-9 indicated an axial orientation of the corresponding substituents while the couplings of H-2 required a *cis*-orientation of H-1 and H-2. The stereochemistry could be elucidated by NOE difference spectroscopy. Clear effects were observed between H-6α, H-7 and H-14', between H-12, H-7, H-8β and H-13, between H-15, H-3 and H-6β, between H-5, H-1 and H-13', between H-14 and OH, as well as between H-14', H-6α and H-9. These results required the proposed configurations at the chiral centres if the usual 7β-isopropenyl stereochemistry was valid. The resulting configurations at C-5 and C-10 should therefore be reversed with respect to that of most eudesmanes. Similar eudesmanolides are however well known [3, 4]. Most likely compounds **18–22** were formed via the epoxide **17**, which itself could be the result of epoxidation of a germacrane derivative in a conformation with C-10 below the plane. However, the relative position of the ester groups was not yet clear. Comparison of the chemical shifts of H-1, H-2 and H-9 in the spectra of **18–20** indicated that the tiglate should be placed at C-1 or C-9 as the signals of the corresponding protons and those at C-14 were influenced by the nature of the ester groups. A final decision was made possible by INEPT experiments which showed that only on irradiation of H-1 did the tiglate carbonyl singlet appear in the ^{13}C NMR spectrum. Similar irradition of H-2 and H-9 led to the appearance of the acetate carbonyl signals. The ^{13}C NMR spectrum (see Experimental) also supported the structure. The observed chemical shift of C-1 and C-5 required γ-effects. The couplings of H-7 indicated that the substituents at C-7 and C-9 were not strictly diaxial. Inspection of a model supported a slightly twisted conformation.

The ^{1}H NMR spectra of **19** and **20** (Table 3) showed that the corresponding senecioate and isovalerate were present. In the spectra of **21** and **22** the H-14 signals were shifted down field and an additional acetate methyl singlet was visible. Furthermore the typical signals of an angelate residue were observed in the spectrum of **22** while those of **21** again indicated the presence of a tiglate. The relative position of the ester groups was determined by acetylation of **18** which led to the formation of **21**. Thus compound **21** was also a 1α-tigloyloxy derivative. As the chemical shifts in the spectrum of **22** were nearly identical with those of **21**, a 1α-angeloyloxy compound was most likely. The 1-des-acyloxy derivative of **18–20** has been named polyachyrol.

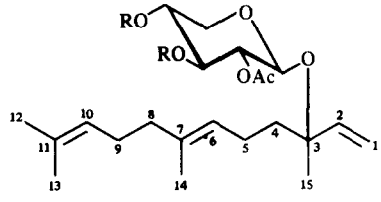
The ^{1}H NMR spectrum of **23** (Table 4) was in part



17



	18	19	20	21	22
R^1	H	H	H	Ac	Ac
R^2	Tigl	Se	*i*Val	Tigl	Ang



23 R = H
23a R = Ac

Table 3. ^{1}H NMR spectral data of compounds **18**–**22** (400 MHz, C_6D_6, δ-values)

H	18	19	20	21	22	Multiplicity
1	5.61	5.64	5.55	5.56	5.59	*dd*
2	5.88	5.89	5.80	5.88	5.88	*br dd*
3	5.35	5.35	5.28	5.25	5.24	*dq*
5	2.74	2.76	2.73	2.80	2.80	*br d*
6α	1.15	1.17	1.16	1.15	1.15	*ddd*
6β	1.90	1.90	1.91	1.95 *m*	1.95 *m*	*br d*
7	2.03	2.03	2.01	2.01	2.00	*br dddd*
8α	1.92	1.93	1.90	1.95 *m*	1.95	*ddd*
8β	2.25	2.28	2.24	2.25	2.25	*br d*
9	5.79	5.83	5.78	5.56	5.55	*t*
12	1.58	1.61	1.59	1.58	1.57	*br s*
13	4.83	4.84	4.83	4.81	4.80	*br s*
13′	4.68	4.70	4.68	4.66	4.64	*br s*
14	4.44	4.48	4.44	5.03 *d*	5.00 *d*	*br d*
14′	3.85	3.87	3.84	4.33 *dd*	4.33 *dd*	*br t*
15	1.41	1.42	1.40	1.38	1.36	*d*
OAc	1.89	1.94	1.92	1.90	1.90	*s*
	1.72	1.74	1.76	1.85	1.81	*s*
				1.80	1.79	*s*
OCOR	6.98 *qq*	5.70 *br s*	2.16 *m*	7.05 *qq*	5.82 *dd*	
	1.34 *dq*	1.38 *d*	0.88 *d*	1.45 *dq*	2.12 *dq*	
	1.83 *br s*	2.12 *d*	0.91 *d*	1.90 *br s*	2.01 *dq*	
OH	2.44	2.53	2.36	—	—	*br d*

J [Hz]: 1,2 = 6; 1,14′ = 1; 2,3 = 4; 3,15 = 1.5; 5,6α = 6α,6β = 12; 6α,7 = 6; 6β,7 ~ 2; 7,8α = 3; 7,8β ~ 2; 8α,8β = 15; 8α,9 = 8β, 9 = 3; 14,14′ = 12.4; 14′, OH = 10.5; OTigl: 3,4 = 7; 3,5 = 4,5 = 1; OAng: 3,4 = 7; 3,5 = 4,5 = 1.5; O*i*Val: 3,4 = 3,5 = 7.

Table 4. ^{1}H NMR spectral data of compounds **23** and **23a** (400 MHz, $CDCl_3$, δ-values)

H	23*	23a†	multiplicity
1t	5.20	5.18	*br d*
1c	5.25	5.23	*br d*
2	5.75	5.72	*dd*
4	1.55	1.55	*m*
5,9	1.96	1.96	*q*
6,10	5.07	5.07, 5.05	*br t*
8	2.02	2.02	*br t*
12	1.67	1.67	*br s*
13	1.56	1.56	*br s*
14	1.59	1.59	*br s*
15	1.34	1.32	*s*
1′	4.60	4.56	*d*
2′	4.71	4.92	*dd*
3′	3.38 *m*	5.14	*t*
4′	3.69 *m*	4.94	*ddd*
5_1′	4.05	4.07	*dd*
5_2′	3.31	3.27	*dd*

*OAc: 2.12 *s*; †OAc: 2.04, 2.02 (6H) *s*.

J [Hz]: 1t, 2 = 17; 1c, 2 = 10; 4, 5 = 5,6 = 8, 9 = 9, 10 = 7; 1′,2′ = 7.5; 2′,3′ = 3′,4′ = 9; 4′,5_1′ = 5.5; 4′,5_2′ = 9;5_1′,5_2′ = 12.

similar to that of nerolidol. However, a set of additional low field signals indicated the presence of a sugar moiety. Furthermore, an acetate group showed a singlet at δ 2.12. In the spectrum of the corresponding acetate **23a** (Table 4) all signals could be assigned by spin decoupling. The resulting sequences showed that the triacetate of nerolidol-β-xylopyranoside was present. The nature of the sugar part followed from the couplings of its protons and from comparison with the spectra of other xylopyranosides [5]. Inspection of the spectrum of **23** and spin decoupling showed that the acetate group was at C-2′.

The isolation of highly oxygenated sesquiterpenes may be of chemotaxonomic relevance. So far highly oxygenated germacrane derivatives have only been reported, together with other characteristic compounds, from a *Trixis* species, also a member of the subtribe *Nassauviinae* [6].

Highly oxygenated germacranolides are present in *Dicoma* species [7] which, however, belongs to the subtribe Gochnatiinae. More species will have to be studied in order to ascertain the chemotaxonomic relevance of these type of compounds.

EXPERIMENTAL

The aerial parts of *Oxyphyllum ulicinum* (647 g, collected 13 km E of Tal Tal, N Chile, February 1987, voucher Conc. 72994) were extracted with MeOH–Et_2O–petrol (1:1:1) and the

extract defatted with MeOH and sepd by CC (silica gel) into three crude fractions. The first one (Et_2O–petrol, 1:9) gave 30 mg lupenone, the second one contained a complex mixture of acids (Et_2O–petrol, 1:1 and Et_2O) and the last one gave 10 mg caffeic acid. The second fraction was treated with CH_2N_2 and the mixture obtained was separated by flash chromatography (silica gel, ϕ 30–60 μ) into two crude fractions (Fr. 2/1, Et_2O–petrol, 1:1 and Fr. 2/2, Et_2O) which gave by crystallization 360 mg lup-20-ene-3β,16β-diol. HPLC (MeOH–H_2O, 4:1, RP 8, flow rate 3 ml/min in all separations) of fr. 2/1 afforded four mixtures (Fr. 2/1/1–2/1/4), 800 mg **1** (R_t 3.0 min) and 50 mg **6** (R_t 5.0 min). HPLC of Fr. 2/1/1 (MeOH–H_2O, 7:3) gave 3 mg **4** (R_t 5.7 min) and 3 mg **10** (R_t 18.7 min). HPLC of Fr. 2/1/2 (MeOH–H_2O, 3:1) gave 30 mg **2** (R_t 12.0 min), 10 mg **3** (R_t 12.6 min), 5 mg **14** (R_t 13.8 min) and 3 mg **5** (R_t 15.8 min). HPLC of Fr. 2/1/3 (MeOH–H_2O, 4:1) gave 7 mg **13** (R_t 7.1 min), 5 mg **11** (R_t 9.4 min), 2 mg **9** (R_t 12.8 min) and a mixture (R_t 11.1 min) which gave by TLC (Et_2O–petrol, 1:3, six developments) 3 mg **7** (R_f 0.50) and 2 mg **8** (R_f 0.45). HPLC of Fr. 2/1/4 (MeOH–H_2O, 17:3) gave 5 mg **12** (R_t 10.7 min) and 7 mg **15** (R_t 11.7 min).

The defatted extract of the aerial parts of *Polyachyrus fuscus* (410 g, collected 25 km N of Tal Tal, N Chile, in February 1987, voucher Conc. 72995) gave by CC two polar fractions (Fr. 1: Et_2O–petrol, 3:1; Fr. 2: Et_2O and Et_2O–MeOH, 9:1) Flash chromatography (silica gel, ϕ 30–60 μ) of fraction 1 gave a mixture of esters which were separated by HPLC (MeOH–H_2O, 4:1, RP 8, flow rate 3 ml/min in all separations) into three crude fractions (Fr. 1/1: R_t 4.4 min, Fr. 1/2: R_t 5.0 min and Fr. 1/3: R_t 5.6 min). TLC of fraction 1/1 (Et_2O–petrol, 1:1, two developments) gave 25 mg **18** (R_f 0.55) and TLC of fraction 1/2 (Et_2O–petrol, 1:1, three developments) afforded 4 mg **21** (R_f 0.62) and 9 mg **19** (R_f 0.55). TLC of fraction 1/3 (Et_2O–petrol, 1:1, two developments) gave 2 mg **22** (R_f 0.65) and 8 mg crude **20** which was purified by HPLC (MeOH–H_2O, 4:1, R_t 6.0 min). Further CC of fraction 2 (Et_2O) followed by TLC (Et_2O) gave 400 mg **23** (R_f 0.5) which was purified as its diacetate **23a** (TLC: Et_2O–petrol, 1:1, R_f 0.65). Known compounds were identified by comparing the 400 MHz ^1H NMR spectra with those of authentic material.

*Methyl-9β-acetoxy-*14-O-[2-*methylbutyryl*]-*oxyphylloate* (**1**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1740, 1240 (OAc), 1720 (C=CCO_2R); MS *m/z* (rel. int.): 422.230 $[M]^+$ (5) (calc. for $C_{23}H_{34}O_7$: 422.230), 390 $[M-MeOH]^+$ (0.6), 362 $[M-AcOH]^+$ (0.3), 307 $[M-CH_2OCOC_4H_9]^+$ (0.3), 260 $[362-RCO_2H]^+$ (3), 247 $[362-CH_2OCOC_4H_9]^+$ (3.5), 85 $[RCO]^+$ (56), 57 $[85-CO]^+$ (100); $[\alpha]_D^{24°}$ −93° ($CHCl_3$; *c* 0.92).

Compound **1** (15 mg) in 2 ml C_6H_6 was refluxed for 5 hr with 30 mg DBU. The usual work-up and TLC (Et_2O–petrol, 1:1) gave 6 mg **13** (R_f 0.60, identical with the isolated product) and 5 mg **16** (R_f 0.52); colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1740 (CO_2R), 1640 (C=C); MS *m/z* (rel. int.): 422.230 $[M]^+$ (1) (calc. for $C_{23}H_{34}O_7$: 422.230), 363 $[M-OAc]^+$ (1.5), 362 $[M-AcOH]^+$ (0.4), 260 $[362-RCO_2H]^+$ (4), 228 $[260-MeOH]^+$ (3), 85 $[RCO]^+$ (42), 57 $[85-CO]^+$ (100). To 30 mg **1** in 2 ml MeOH, 100 mg KOH in 0.5 ml H_2O was added. After 30 sec at 20° dil. H_2SO_4 was added. Work-up followed by TLC (Et_2O–petrol, 3:1) gave 12 mg **1** and 8 mg **10**, identical with the isolated product.

*Methyl-9β-acetoxy-*14-O-*isobutyryl-oxyphylloate* (**2**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1740 (CO_2R), 1720 (C=CCO_2R); MS *m/z* (rel. int.): 408.215 $[M]^+$ (4.5) (calc for $C_{22}H_{32}O_7$: 408.215), 376 $[M-MeOH]^+$ (0.6), 348 $[M-AcOH]^+$ (0.3), 307 $[M-CH_2OCOC_3H_7]^+$ (0.3), 260 $[348-RCO_2H]^+$ (2.9), 247 $[348-CH_2OCOC_3H_7]^+$ (4.3), 71 $[RCO]^+$ (100); $[\alpha]_D^{24°}$ −92 ($CHCl_3$; *c* 2.86).

*Methyl-9β-acetoxy-*14-O-n-*butyryl-oxyphylloate* (**3**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1740 (CO_2R), 1720 (C=CCO_2R); MS *m/z* (rel. int.): 408.215 $[M]^+$ (4) (calc. for $C_{22}H_{32}O_7$: 408.215), 376 (0.6), 348 (0.3), 260 (3), 247 $[348-CH_2OCOC_3H_7]^+$ (3.7), 71 (100).

*Methyl-9β-acetoxy-*14-O-*propionyl-oxyphylloate* (**4**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1740 (CO_2R), 1715 (C=CCO_2R); MS *m/z* (rel. int.): 394.199 $[M]^+$ (3.7) (calc. for $C_{21}H_{30}O_7$: 394.199), 362 (0.6), 334 (0.3), 260 (2.5), 247 $[334-CH_2OCOEt]^+$ (3.7), 228 (2.5), 57 $[RCO]^+$ (100).

*Methyl-9β-acetoxy-*14-O-*senecioyl-oxyphylloate* (**5**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1740 (OAc), 1720 (C=CCO_2R); MS *m/z* (rel. int.): 420.215 $[M]^+$ (2.3) (calc. for $C_{23}H_{32}O_7$: 420.215), 388 (0.3), 360 (0.2), 260 (1), 247 $[360-CH_2OCOC_4H_7]^+$ (1.2), 83 $[RCO]^+$ (100).

*Methyl-9β-senecioyloxy-*14-O-[2-*methylbutyryl*]-*oxyphylloate* (**6**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1730 (CO_2R), 1720 (C=CCO_2R); MS *m/z* (rel. int.): 462.262 $[M]^+$ (7.4) 430, (0.3), 362 (0.3), 247 $[362-CH_2OCOC_4H_7]^+$ (2.1), 260 (2.3), 85 $[RCO]^+$ (18), 83 $[RCO]^+$ (100); $[\alpha]_D^{24°}$ −79° ($CHCl_3$; *c* 2.07).

*Methyl-9β-senecioyloxy-*14-O-*isobutyryl-oxyphylloate* (**7**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1735 (CO_2R), 1715 (C=CCO_2R); ms *m/z* (rel. int.): 448.246 $[M]^+$ (3) (calc. for $C_{25}H_{36}O_7$: 448.246), 360 (0.1), 348 (0.2), 247 $[348-CH_2OCOC_3H_7]^+$ (1.2), 260 (1.3), 83 $[RCO]^+$ (100), 71 $[RCO]^+$ (20).

*Methyl-9β-senecioyloxy-*14-O-n-*butyryl-oxyphylloate* (**8**) Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1735 (CO_2R), 1715 (C=CCO_2R); MS *m/z* (rel. int.): 448.246 $[M]^+$ (4) (calc. for $C_{25}H_{36}O_7$: 448.246), 360 (0.1), 348 (0.4), 247 $[348-CH_2OCOC_3H_7]^+$ (1.5), 260 (1.3), 83 $[RCO]^+$ (100), 71 $[RCO]^+$ (24).

*Methyl-9β-senecioyloxy-*14-O-*senecioyloxy-oxyphylloate* (**9**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1730 (CO_2R); MS *m/z* (rel. int.): 460.246 $[M]^+$ (5.5) (calc. for $C_{26}H_{36}O_7$: 460.246), 360 (0.5), 260 (2.3), 247 $[360-CH_2OCOC_4H_7]^+$ (2), 83 $[RCO]^+$ (100).

*Methyl-9β-hydroxy-*14-O-[2-*methylbutyryl*]-*oxyphylloate* (**10**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3580 (OH), 1735 (CO_2R) 1720 (C=CCO_2R); MS *m/z* (rel. int.): 380.220 $[M]^+$ (1.7) (calc. for $C_{21}H_{32}O_6$: 380.220), 362 $[M-H_2O]^+$ (0.2), 348 (0.4), 278 (1.5), 247 $[362-CH_2OCOC_4H_9]^+$ (1.1), 85 $[RCO]^+$ (58), 57 $[85-CO]^+$ (100).

Compound **10** (3 mg) were heated with 0.5 ml Ac_2O for 1 hr at 70°. TLC (Et_2O–petrol, 1:1) gave 2 mg **1**, identical with the isolated product.

*Methyl-*14-O-[2-*methylbutyryl*]-*oxyphylloate* (**11**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1735 (CO_2R), 1715 (C=CCO_2R); MS *m/z* (rel. int.): 364.225 $[M]^+$ (1) (calc. for $C_{21}H_{32}O_5$: 364. 225), 332 (0.5), 262 (1.5, 245 $[M-CH_2OCOC_4H_9]^+$ (1), 230 (1.5), 85 $[RCO]^+$ (41), 57 $[85-CO]^+$ (100); $[\alpha]_D^{24°}$ −46° ($CHCl_3$; *c* 0.32).

Methyl-9β-[2-*methylbutyryloxy*]-14-O-[2-*methylbutyryl*]-*oxyphylloate* (**12**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1730 (CO_2R), 1720 C=CCO_2R); MS *m/z* (rel. int.): 464.277 $[M]^+$ (5) (calc. for $C_{26}H_{40}O_7$: 464.277), 432 (0.5), 362 (0.5), 330 (0.5), 260 (2.8), 247 $[362-CH_2OCOC_4H_9]^+$ (2.7), 85 $[RCO]^+$ (48), 57 $[85-CO]^+$ (100), $[\alpha]_D^{24°}$ −71° ($CHCl_3$; *c* 0.41).

*Methyl-*4E-9β-*acetoxy-*14-O-[2-*methylbutyryl*]-*oxyphylloate* (**13**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1745 (CO_2R), 1715 (C=CCO_2R); MS *m/z* (rel. int.): 422.230 $[M]^+$ (7) (calc. for $C_{23}H_{34}O_7$: 422.230), 362 (0.4), 260 (3), 247 $[362-CH_2OCOC_4H_9]^+$ (1.8), 228 (2), 85 $[RCO]^+$ (51), 57 $[85-CO]^+$ (100); $[\alpha]_D^{24°}$ −82° ($CHCl_3$; *c* 0.36).

*Methyl-*4E-9β-*acetoxy-*14-O-*isobutyryl-oxyphylloate* (**14**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1745 (CO_2R), 1715 (C=CCO_2R); MS *m/z* (rel. int.): 408.215 $[M]^+$ (4.5) (calc. for $C_{22}H_{32}O_7$: 408.215), 348 (0.4), 260 (3.2), 247 $[348-CH_2OCOC_3H_7]^+$ (2.7), 71 $[RCO]^+$ (100); $[\alpha]_D^{24°}$ −92° ($CHCl_3$; *c* 0.54).

*Methyl-*4E-9β-*senecioyloxy-*14-O-[2-*methylbutyryl*]-*oxyphylloate* (**15**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1730 (CO_2R), 1720 (C

$=CCO_2R$); MS *m/z* (rel. int.): 462.262 $[M]^+$ (3) (calc. for $C_{26}H_{38}O_7$: 462.262), 362 (0.3), 260 (1.4), 247 [362 $-CH_2OCOC_4H_9]^+$ (1), 85 $[RCO]^+$ (35), 83 $[RCO]^+$ (100), 57 (64), 55 (16); $[\alpha]_D^{24^\circ}$ -82° ($CHCl_3$; *c* 0.69).

1α-*Tigloyloxypolyachyrol* (**18**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3590 (OH), 1745 (OAc), 1725 ($C=CCO_2R$); MS *m/z* (rel. int.): 374.209 $[M-HOAc]^+$ (0.5) (calc. for $C_{22}H_{30}O_5$: 374. 209), 334 $[M-RCO_2H]^+$ (1.3), 314 $[374-HOAc]^+$ (3.3), 291 (5.5), 201 (18), 185 (14), 83 $[RCO]^+$ (100), 55 $[83-CO]^+$ (41); ^{13}C NMR (C_6D_6, C-1–C-15): 66.8, 72.5, 118.4, 141.8, 36.1, 24.1, 36.2, 25.9, 68.2, 43.9, 147.3, 20.6, 108.7, 60.8, 22.4; OAc: 168.9, 169.4, 20.3, 20.6; OTigl: 166.3, 128.4, 137.9, 13.8, 12.0 (assignment by 2D $^{13}C-^1H$-correlated spectrum); $[\alpha]_D^{24^\circ}$ $+189^\circ$ ($CHCl_3$; *c* 0.60). Compound **18** (5 mg) were heated with 0.5 ml Ac_2O for 1 hr. TLC gave 4 mg **21**, identical with the natural product.

1α-*Senecioyloxypolyachyrol* (**19**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3590 (OH), 1740 (OAc), 1720 ($C=CCO_2R$); MS *m/z* (rel. int.): 374.209 $[M-HOAc]^+$ (0.4) (calc. for $C_{22}H_{30}O_5$: 374.209), 334 (0.3), 314 (3.3), 291 (5.5), 201 (18), 83 (100), 55 (21); $[\alpha]_D^{24^\circ}$ $+179^\circ$ ($CHCl_3$; *c* 0.82).

1α-*Isovaleryloxypolyachyrol* (**20**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3590 (OH), 1745 (OAc, CO_2R); MS *m/z* (rel. int.): 376.225 $[M-HOAc]^+$ (0.6) (calc. for $C_{22}H_{32}O_5$: 376.225), 334 $[M-RCO_2H]^+$ (8), 316 (4), 291 (10), 201 (97), 159 (98), 85 (51), 57 (100); $[\alpha]_D^{24^\circ}$ $+113^\circ$ ($CHCl_3$ *c* 0.65).

1α-*Tigloyloxypolyachyrol*-14-O-*acetate* (**21**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1740 (OAc), 1720 ($C=CCO_2R$); MS *m/z* (rel. int.): 416.219 $[M]^+$ (0.3) (calc. for $C_{24}H_{32}O_6$: 416.220), 334 $[M-O=C=C(Me)-CH=CH_2]^+$ (18), 201 (36), 83 $[RCO]^+$ (100), 55 $[83-CO]^+$ (43); $[\alpha]_D^{24^\circ}$ $+88^\circ$ ($CHCl_3$; *c* 0.8).

1α-*Angeloyloxypolyachyrol*-14-O-*acetate* (**22**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1740 (OAc), 1720 ($C=CCO_2R$); MS *m/z* (rel. int.): 416.220 $[M]^+$ (0.6) (calc. for $C_{24}H_{32}O_6$: 416.220), 356 $[M-HOAc]^+$ (0.3), 334 (11), 201 (28), 83 $[RCO]^+$ (100), 55 $[83-CO]^+$ (57).

Nerolidol-[2-O-*acetyl*-β-D-*xylopyranoside*] (**23**). Colourless oil; ^1H NMR see Table 4. Acetylation (Ac_2O, DMAP $CHCl_3$, 1 hr, 70°) gave **23a**, colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1750, 1250, (OAc); MS *m/z* (rel. int.): 259 $[C_{11}H_{15}O_7]^+$ (14), 205 $[C_{15}H_{25}]^+$ (20), 199 $[259-HOAc]^+$ (18), 157 $[199-ketene]^+$ (70), 139 $[199-HOAc]^+$ (72), 97 $[139-ketene]^+$ (96), 69 $[C_5H_9]^+$ (100); $[\alpha]_D^{24^\circ}$ -21° ($CHCl_3$; *c* 1.39).

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