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EREMOPHILANE DERIVATIVES AND OTHER CONSTITUENTS FROM *HAECKERIA* SPECIES AND FURTHER AUSTRALIAN INULEAE

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Key Word Index—*Haeckeria pholidota, H. punctulata; Cassinia arcuata, C. leptocephala; Calomeria amaranthoides; Cratystylis microphylla*; Compositae; sesquiterpenes; sesquiterpene acids; eremophilanes; eudesmanes; germacranes; sesquiterpene lactones.

Abstract—From the aerial parts of two *Haeckeria* species, in addition to known compounds, 19 new eremophilan-12-oic acids, one being a *seco-nor* derivative, two eudesman-12-oic acids and three germacran-12-oic acids were isolated. The other species only gave known compounds which in part are of taxonomic relevance. The structures were elucidated by high field NMR spectroscopy. The chemotaxonomic aspects are discussed briefly.

INTRODUCTION

The small Australian genus *Haeckeria*, previously part of the genus *Humea* [1], is placed in the tribe Inuleae. As the result of a reinvestigation, the tribe has recently been divided into the Inuleaes s. str., the Gnaphalieae and the Plucheae [2]. As nothing was known on the chemistry of *Haeckeria*, we have investigated two species of this genus and several other Australian taxa, of allegedly related genera.

RESULTS AND DISCUSSION

The extract of the aerial parts of *Haeckeria pholidota* (F. Muell) J. H. Willis gave tridecapentaynene, palustrol (**51**) [3], the eremophilanes **2–5**, **8–10** and **12–23**, the *seco-nor* derivative **24** and the eudesmane **36**. All acids were isolated as their methyl esters **2a**, **3a** etc.

The structure of **51** has been determined indirectly by X-ray analysis of an air oxidation product with an additional hydroxy group at C-4 [3]. We have studied again the configuration at C-4 as the oxidation could have induced a change. A clear NOE between H-4 and H-5 (4%), between OH and H-6 (7%) as well as between H-12 and H-5 (8%) established the proposed stereochemistry. The presented ^{13}C NMR data agreed with those of our sample.

The structure of **2a** followed from its ^1H NMR spectrum (Table 1). All signals could be assigned by spin decoupling leading to a sequence which only agreed with the proposed structure. Inspection of a model further showed that a 3β-acetoxy derivative was present. The corresponding alcohol has been reported previously [4]. The acid **3** has been isolated already from a *Stevia* species [4]. The ^1H NMR data of the methyl ester **3a** differed in the expected way.

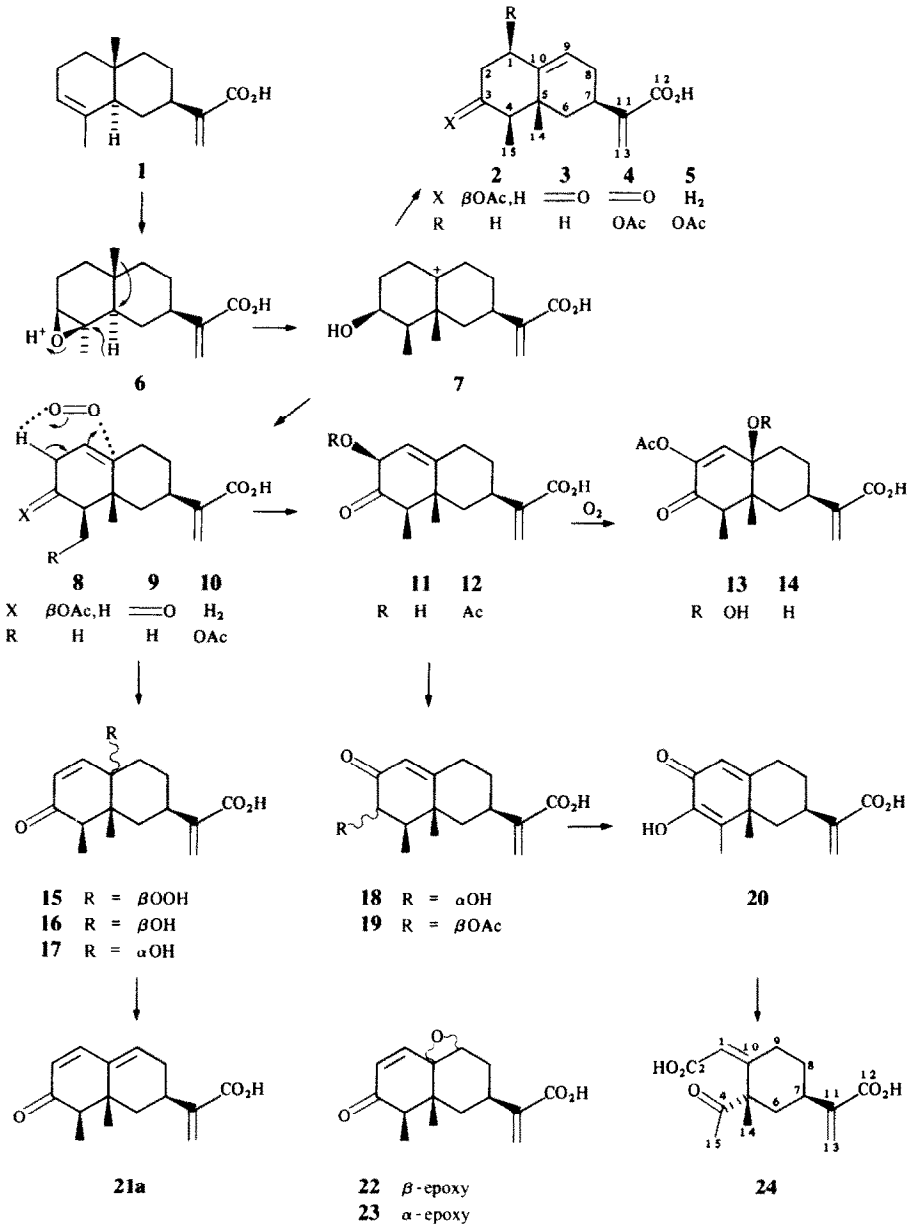
The ^1H NMR spectrum of **4a** (Table 1) was in part similar to that of **3a**. However, a three proton singlet at δ1.99 and a triplet at 5.66 required an additional acetoxy function which could only be placed at C-1 as followed from the results of spin decoupling. The configuration at C-1 was deduced from the couplings and the pronounced downfield shift of H-9. In the mass spectrum of **4a**, a strong fragment (*m/z* 204) was due to loss of C-3, C-4 and C-15 from the ion of the base peak formed by loss of acetic acid. The same fragmentation was observed in the mass spectrum of **9a**, **18a** and **19a**.

The ^1H NMR spectrum of **5a** (Table 1) was similar to that of **4a**. Spin decoupling showed that the keto group at C-3 was missing as H-4 showed additional couplings. Accordingly, the presence of the corresponding 3-desoxo derivative of **4a** was very likely. The configuration at C-1 again was deduced from the observed couplings. Further support was obtained from NOED. In particular effects of H-4 with H-1 (1%) and H-9 with H-1 (8%) agree only with the proposed stereochemistry. Further effects between H-14 and H-15 (5%) as well as of H-7 with H-4 (5%) established the configuration at C-4, C-5 and C-7.

The molecular formula of **8a** indicated that it is an isomer of **2a**. The ^1H NMR spectrum (Table 1) showed that again an 3β-acetoxy eremophilane derivative must be present. Accordingly, H-4 was a doublet of quartets and H-3 a double triplet. Irradiation of the latter signal changed those at δ2.41 and 2.14. As the corresponding protons also coupled with the olefinic signal at δ5.32 the presence of a 1(10)-double bond was established.

Spin decoupling of the ^1H NMR spectrum of **9a** (Table 1) clearly showed that we were dealing with the corresponding 3-keto derivative of desacetoxy **8a**. Accordingly, three-fold doublets at δ2.93 and 2.80 were due to H-2, both showing homoallylic couplings with H-9. The conformation of all eremophilanes differs slightly as can be deduced from the couplings of H-7. Obviously, the substituents and the position of the double bond are responsible for this effect.

The ^1H NMR spectrum of **10a** (Table 1) clearly shows that a 15-acetoxy derivative of 2-desoxo-tessaric acid [5]



was present as followed from a pair of double doublets at δ4.18 and 3.87.

The molecular formula of **12a** was $C_{18}H_{24}O_5$. There, in agreement with the ^{1}H NMR spectrum (Table 1) the presence of a keto acetate derived from desoxotessaric acid was very likely. The position of the keto group followed from the absence of additional couplings of H-4 and that of the acetoxy group from the vicinal and homoallylic coupling of H-2. NOE's between H-4, H-2 (7%) and H-7 (6%) established the stereochemistry and a negative Cotton effect supports the proposed absolute configuration which most likely is valid for all the isolated acids.

The ^{1}H NMR spectra of **13a** and **14a** (Table 1) were in part similar to those of **15a** and **16a** (see below). The absence of the second olefinic proton signal and the presence of an acetoxy group indicated that most likely 1- or 2-acetoxy derivatives of **15a** and **16a** (see below) were present. The observed chemical shift of H-1 in the spectrum of **13a** agrees with the expected shielding effect of the acetoxy group. This was further supported by the observed deshielding effect of the hydroperoxy group. Triphenylphosphine reduction of **14a** afforded a carbinol which was identical with **13a**.

The ^{1}H NMR spectra of **15a** and **16a** (Table 2) showed that we were dealing with the desacetoxy derivatives of **13a** and **14a**. The spectra differed in the expected way. The downfield shift of H-1 in the spectrum of **15a** was again due to the deshielding effect of the hydroperoxy group. Triphenylphosphine reduction gave a carbinol which was identical with **16a**.

The ^{1}H NMR spectrum of **17a** (Table 2) differed characteristically from that of **16a**, although spin decoupling led to the same sequence. Inspection of models indicated

Table 1. ^{1}H NMR spectral data of compounds **2a**, **4a**, **5a**, **8a**–**10a** and **12a**–**14a** ($CDCl_3$, 400 MHz, δ-values)

H	**2a**	**4a**	**5a**	**8a**	**9a**	**10a**	**12a**	**13a**†	**14a**
1	2.46 *t*	5.66 *t*	5.25 *t*	5.32 *br t*	5.46 *br dd*	5.42 *br t*	5.44 *dd*	6.69 *s*	6.22 *s*
2	1.98 *br d* 1.56 *dddd*	2.69 *d*	1.62 *m* 1.45 *m*	2.41 *ddt* 2.14 *ddt*	2.93 *ddd* 2.80 *dt*	2.04 *m*	5.79 *dd*	—	—
3	5.09 *q*	—	*	5.07 *dt*	—	1.61 *m* 1.43 *m*	—	—	—
4	1.93 *dq*	2.78 *q*	1.74 *m*	1.75 *dq*	2.78 *q*	1.74 *m*	2.98 *q*	3.05 *q*	2.99 *q*
6	1.90 *br d*	2.02 *dt*	1.95 *dt*	1.67 *dd*	1.75 *dt*	1.74 *m*	1.77 *br d*	1.70 *m*	1.70 *br d*
6′	0.94 *t*	1.29 *dd*	1.13 *dd*	1.44 *dd*	1.44 *dd*	1.61 *m*	1.49 *dd*	1.42 *dd*	1.41 *dd*
7	2.62 *br t*	2.75 *br t*	2.65 *br t*	2.56 *m*	2.64 *br dt*	2.60 *m*	2.65 *br q*	2.71 *tt*	2.69 *br t*
8	2.08 *m*	2.28 *ddddd*	2.11 *m*	2.06 *m*	1.93 *ddd*	1.83 *m*	1.95 *m*	1.75 *m*	2.08 *m*
8′	1.90 *m*	2.06 *ddd*	1.70 *m*	1.75 *m*	1.63 *dddd*	1.74 *m*	1.71 *m*	1.58 *m*	1.99 *dt*
9	5.45 *dt*	6.07 *dd*	5.81 *dd*	2.47 *m* 2.06 *m*	2.40 *br q* 2.16 *ddd*	2.39 *m* 2.02 *ddd*	2.41 *dddt* 2.22 *ddd*	2.55 *dt* 1.88 *dt*	2.16 *m* 1.70 *m*
13	6.18 *br s*	6.25 *br s*	6.18 *br s*	6.12 *br s*	6.18 *br s*	6.12 *br s*	6.19 *br s*	6.23 *br s*	6.23 *br s*
13′	5.51 *br s*	5.57 *br s*	5.51 *br s*	5.54 *br s*	5.55 *br s*	5.54 *br s*	5.56 *br s*	5.60 *br s*	5.60 *br s*
14	1.14 *s*	1.00 *s*	1.01 *s*	1.12 *s*	0.84 *s*	0.95 *s*	0.88 *s*	0.90 *s*	0.92 *s*
15	0.90 *d*	1.04 *d*	0.87 *d*	0.95 *d*	1.03 *d*	4.18 *dd* 3.87 *dd*	1.04 *d*	1.16 *d*	1.18 *d*
OMe	3.76 *s*	3.77 *s*	3.75 *s*	3.75 *s*	3.76 *s*	3.75 *s*	3.76 *s*	3.77 *s*	3.77 *s*
OAc	2.08 *s*	1.99 *s*	2.01 *s*	2.04 *s*	—	2.05 *s*	2.16 *s*	2.23 *s*	2.22 *s*

*Overlapped multiplet.

†OOH 7.59 s.

J [Hz]: Compound **2a**: 1,9 = 8′,9 = 1.5; 2,3 = 2′,3 = 3,4 = 3; 4,15 = 7; 6α,6β = 6β,7 = 7,8β ~ 12; 8,9 = 6; compound **4a**: 1,2 = 4; 4,15 = 7; 6,6′ = 13; 6,7 = 6,8 = 2; 6′,7 = 12; 7,8 = 3; 7,8′ = 11; 8,8′ = 17; 8,9 = 6.5; 8′,9 = 2; compound **5a**: 1,2 = 2.5; 4,15 = 6; 6,6′ = 13; 6,7 = 6,8 = 2.5; 6′,7 = 7,8′ = 12; 8,9 = 6; 8′,9 = 2; compound **8a**: 1,2 = 1,2′ ~ 3; 2,2′ = 17; 2,9 = 2,9′ = 2′,9 = 2′,9′ ~ 2.5; 4,15 = 7; 6,6′ = 13; 6,7 = 7,8α ~ 3; 6′,7 = 10; compound **9a**: 1,2 = 4; 1,2′ = 2,9 = 3; 1,9 = 2; 2,2′ = 22; 4,15 = 7; 6,6′ = 13.5; 6,7 = 6,8 = 2; 6′,7 = 10; 7,8 ~ 8; 7,8′ = 10; 8,8′ = 13; 8,9 ~ 3; 8,9′ = 12; 8,9 ~ 3; 8′,9′ ~ 8; 9,9′ = 14; compound **10a**: 1,2 ~ 3; 4,15 = 3; 4,15′ = 9; 8,9′ = 8; 8′,9′ = 2.5; 9,9′ = 15; 15,15′ = 10.5; compound **12a**: 1,2 = 3.5; 1,9 = 2,9 = 1.5; 4,15 = 6.5; 6,6′ = 13; 6′,7 = 11; 7,8 = 7,8′ ~ 9; 8,9 ~ 8; 8′,9 = 10; 8,9′ = 2; 8′,9′ = 8; 9,9′ = 14; compound **13a**: 4,15 = 7; 6,6′ = 14; 6′,7 = 7,8 = 12; 6,7 = 7,8′ = 8,9 = 3; 8,9′ = 9,9′ = 15; compound **14a**: 4,15 = 7,6,6′ = 14; 6′,7 = 7,8 = 12; 7,8′ = 8′,9 ~ 3; 9,9′ = 14.

Table 2. ^{1}H NMR spectral data of compounds **15a**–**24a** (400 MHz, $CDCl_3$, δ-values)

	15a	**16a**	**17a**	**18a**	**19a**	**20a**	**21a**	**22a**	**23a**	**24a**
	7.02 *d*	6.54 *d*	6.55 *d*	5.96 *br d*	5.96 *d*	6.26 *d*	6.97 *d*	6.25 *d*	6.17 *d*	5.86 *br s*
	6.00 *d*	5.93 *d*	5.91 *d*	—	—	—	5.86 *d*	6.17 *d*	6.21 *d*	—
	—	—	—	3.99 *dd*	5.46 *d*	—	—	—	—	—
	2.95 *q*	2.91 *q*	2.95 *q*	2.06 *dq*	2.22 *dq*	—	2.63 *q*	2.92 *q*	2.78 *q*	—
	1.67 *br d*	1.70 *br d*	1.66 *br d*	1.81 *br d*	1.95 *br d*	2.17 *dd*	2.11 *ddd*	1.54 *dt*	1.98 *dd*	1.82 *br dd*
	1.40 *dd*	1.38 *dd*	1.38 *dd*	1.33 *m*	1.56 *dd*	1.77 *dd*	1.43 *dd*	1.23 *dd*	1.33 *dd*	1.65 *dd*
	2.71 *tt*	2.70 *br tt*	3.09 *br tt*	2.55 *m*	2.55 *m*	2.67 *tt*	2.78 *br tt*	2.70 *br dt*	3.15 *dddd*	2.75 *br*
	1.73 *m*	1.75 *m*	1.66 *m*	1.95 *m*	2.69 *m*	2.15 *m*	2.37 *ddd*	2.33 *ddt*	2.25 *dd*	1.97 *m*
	1.59 *m*	1.66 *dd*		1.81 *br d*	1.93 *m*	1.85 *m*	2.16 *dddt*	1.75 *dd*		1.55 *m*
	2.48 *dt*	2.02 *dt*	2.00 *m*	2.61 *m*	2.35 *ddd*	2.82 *dddd*	6.09 *dd*	3.38 *d*	3.44 *t*	2.47 *dddd*
	1.84 *dt*	1.91 *ddd*	1.93 *m*	2.34 *ddd*	1.90 *m*	2.47 *ddd*				2.19 *br dt*
3	6.23 *br s*	6.23 *br s*	6.13 *br s*	6.19 *br s*	6.20 *br s*	6.21 *br s*	6.24 *br s*	6.25 *br s*	6.18 *br s*	6.19 *br s*
3′	5.60 *br s*	5.60 *br s*	5.62 *br d*	5.55 *br s*	5.57 *br s*	5.68 *br d*	5.56 *br s*	5.56 *br s*	5.58 *br s*	5.50 *br s*
4	0.82 *s*	0.85 *s*	0.86 *s*	1.17 *s*	1.24 *s*	1.27 *s*	1.00 *s*	0.99 *s*	1.09 *s*	1.44 *s*
5	1.12 *d*	1.14 *d*	1.02 *d*	1.16 *d*	1.00 *d*	1.92 *s*	1.11 *d*	1.12 *d*	1.04 *d*	2.27 *s*
OAc	—	—	—	—	2.12 *s*	—	—	—	—	—
OMe	3.77 *s*	3.77 *s*	3.77 *s*	3.76 *s*	3.76 *s*	3.78 *s*	3.78 *s*	3.77 *s*	3.77 *s*	3.74 *s* 3.66 *s*
OH	7.48 *s* (OOH)	—	—	3.61 *d*	—	6.42 *s*	—	—	—	—

J [Hz]: Compounds **15a**, **16a**, **17a**, **21a**, **22a** and **23a**: 1,2 = 10; 4,15 = 7; 6,6′ = 13; compound **15a**: 6′,7 = 7,8 = 11; 8,9 = 3; 8,9′ = 4; 8′,9 = 3; 8′,9′ = 12; 9,9′ = 13; compound **16a**: 8,8′ = 13; 8,9 = 4.5; 8′,9 = 9,9′ ~ 13; 8′,9′ = 3; compound **17a**: 6,7 = 6′,7 = 7,8 = 7,8′ ~ 3; 7,13′ = 1.5; compound **18a**: 9 = 1; 3,4 = 12; 3,OH = 1.5; 6,6′ = 8,8′ ~ 13; 8,9 = 8,9′ ~ 10; 8′,9 = 2.5; 9,9′ = 14; compound **19a**: 1,9 ~ 1.3; 3,4 = 5; 4,15 = 7; 6,6′ = 14; 6′,7 = 10; 8,9 = 8; 8′,9 = 4; 9,9′ = 14; compound **20a**: 1,9 = 1.3; 6,6′ = 14; 6,7 = 6.5; 6′,7 = 6; 7,8 = 7,8′ = 6.5; 7,13′ = 1.3; 8,9 ~ 10; 8′,9 ~ 7; 8,9′ = 4; 8′,9′ = 6.5; 9,9′ = 14; compound **21a**: 1,8′ = 2,8′ ~ 0.7; 6,7 = 7,8 = 3; 6,8 = 2.5; 6′,7 = 7,8′ ~ 11; 8,8′ = 17; 8,9 = 6; 8′,9 = 3; compound **22a**: 6,7 = 6,8 = 2; 6′,7 = 12; 8,9 = 5.5; compound **23a**: 6,7 = 11; 6′,7 = 5; 7,8 = 10; 8,9 = 2.3; compound **24a**: 1,9 = 1; 6,6′ = 14; 6,7 = 3; 6′,7 = 12; 7,8 = 12; 7,8′ = 3; 8,9 = 7; 8′,9 = 8; 8,9′ = 8′,9′ = 5.5; 9,9′ = 14.

that this is due to the changed configuration at C-10. In the case of **17a** the side chain at C-7 must be axially and in that of **16a** equatorially orientated as followed from the different couplings of H-7.

The ^{1}H NMR spectrum of **18a** (Table 2) showed that a hydroxy derivative of the methyl ester of tessaric acid was present. As H-4 was a doublet of quartets, a 3-hydroxy derivative was very likely. The observed coupling required equatorial orientation of the hydroxy group. This was also supported by the coupling of the hydroxy group which must be hydrogen bonded.

The molecular formula of **19a** was $C_{18}H_{24}O_5$ indicating that an acetate of **18a** may be present. However, the ^{1}H NMR spectrum (Table 2) showed that the configuration at C-3 was different. The observed coupling required a 3β-acetoxy group.

The ^{1}H NMR spectrum of **20a** (Table 2) showed in addition to the signals of H-13, two further lowfield ones at δ6.42 (*s*) and 6.26 (*d*). Spin decoupling indicated that the latter showed an allylic coupling with H-9. As the usual methyl doublet of H-15 present in all the other esters was replaced by a singlet at δ1.92 a changed situation at C-4 had to be proposed. The ^{13}C NMR spectrum (Experimental) required two carbonyl and three double bonds. The observed chemical shifts only agreed with the proposed structure. Deuterium oxide exchange further showed that the singlet at δ6.42 was due to a hydroxy proton.

The spectral data of the main compound **21a** indicated that a conjugated dienone was present. In the ^{1}H NMR spectrum (Table 2), in addition to a pair of low field doublets at δ6.97 and 5.86, a double doublet at δ6.09 was present. Spin decoupling showed that the latter was due to H-9. The ^{13}C NMR spectrum (Experimental) further supports the structure. The observed negative Cotton effect agrees with the proposed absolute configuration.

The esters **22a** and **23a** had the same molecular formula indicating that we were dealing with a pair of isomers. Inspection of the ^{1}H NMR spectrum of **22a** (Table 2) showed that again a conjugated 3-keto derivative with substitution at C-10 was present. The chemical shifts of the olefinic protons differed from those of **15a–17a** and **21a**. A doublet at δ3.38 was due to H-9, as followed from the results of spin decoupling. Thus, most likely a 9,10-epoxide was present which could explain the upfield shift of H-1. This was supported by the ^{13}C NMR spectrum (Experimental). The stereochemistry followed from the NOE's of H-7 with H-4 (10%), H-9 with H-1 (6%) and H-8α (6%). The ^{1}H NMR spectrum of **23a** (Table 2) agreed with the presence of the corresponding 9α,10α-epoxide. The structures of **22a** and **23a** were confirmed by epoxidation of **21a** which gave two epoxides in a ratio of 9:1. Inspection of a model of **21a** shows that steric reasons led to a preferred attack from the β-face.

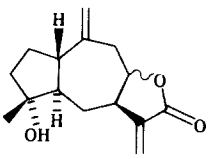
The molecular formula of **24a** was $C_{16}H_{22}O_5$. As the ^{1}H NMR spectrum (Table 2) clearly showed that a dimethyl ester was present, a *nor*-sesquiterpene is proposed. Together with the ^{13}C NMR data (Experimental), all data agreed with structure **24a**, the dimethyl ester of a degradation product of **20**. The configuration of the 1(10)double bond and the stereochemistry at C-4 and C-7 follow from the observed NOE's [H-1 with H-9α (3%) and H-9β (4%), H-14 with H-15 (5%), H-6α (5%) and H-6β (5%), H-7 with H-8α (3%) and H-6α (3%)].

Most likely all the isolated eremophilanes are derived from the epoxide **6** via the ion **7** as shown in the Scheme leading to the acids **2–5** after elimination of a proton at C-9 or to **8–23** after loss of a proton at C-1. The transformation of **9** into **15** must be due to an ene reaction of **9** with oxygen. Similarly after allylic oxidation of **9** the acid **12** can be transformed to **13**. Only the isomer **18** of the acid **11** was isolated, and was most likely formed via the enol of the latter. The ketone **20** was most likely formed via oxidation of **11** or **18** while the dienone **21** is formed by elimination of water from **16**, the reduction product of **15**.

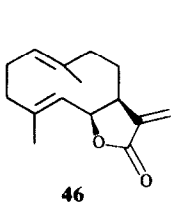
The structure of **36a** followed from its ^{1}H NMR spectrum (Experimental) which in part was similar to those of cuauthemone derivatives [6]. The configuration at C-3 followed from the small vicinal couplings of H-3 while the whole stereochemistry was determined by NOED. Clear effects were observed between H-15, H-14 (5%) and H-3 (8%), between H-14, H-2β (4%), H-6β (4%), H-8β (5%) and H-15 (5%). As H-6β showed a large coupling with H-7 the latter must be α-orientated. The ^{13}C NMR spectrum (Experimental) also agrees with the structure.

The extract of the aerial parts of *H. punctulata* (F. Muell.) J. H. Willis gave the guaianolides **44** [7] and **45** [7], the eremophilane derivatives **2**, **3**, **12** and **21** (see above), the costic acid derivatives **26** [8], **30**, **31** and **32** [9], the acetate **36** (see above) and its epimer **35**, both isolated as their methyl esters, the carbinol **37** [10], the *seco*-caryophyllene derivative **43** [11] and the germacrane derivatives **38–40**.

The structure of **30a** followed from its ^{1}H NMR spectrum (Experimental) which was, as expected, very similar



44 8αH
45 8βH



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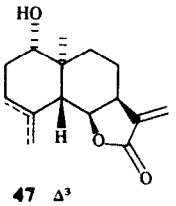
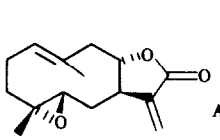


47 Δ^3
48 $\Delta^{4(15)}$



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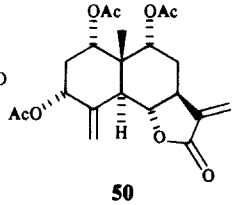

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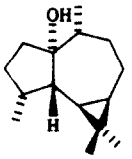
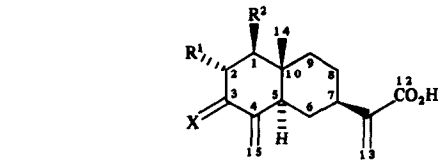
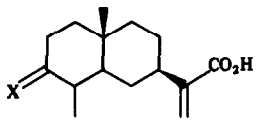


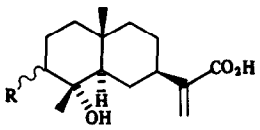
51



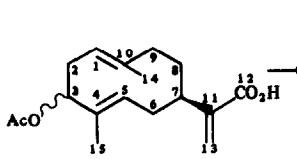
	25	26	27	28	29	30	31	32
R^1	H	OH	OAc	OSen	MeSen	H	H	H
R^2	H	H	H	H	H	H	H	OH
X	H_2	H_2	H_2	H_2	H_2	βOAc	αOAc	H_2



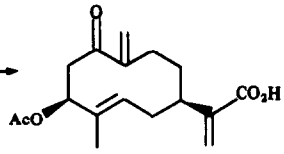
33 X = H_2
34 X = O



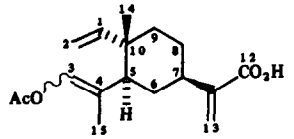
35 R = βOAc
36 R = αOAc
37 R = H,4*epi*



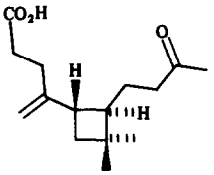
38 3αH
39 3βH



40



41 3*E*
42 3*Z*



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1a–5a,8a–10a,12a–23a and **25a–43a** are the methylesters, **24a** is the dimethylester

to that of the corresponding alcohol [12]. The ^{1}H NMR spectrum of **35a** (Experimental) differed from that of **36a** mainly by the changed couplings of H-3 which required an equatorial acetoxy group. Similarly the ^{1}H NMR spectrum of **31a** (Experimental) shows that we were dealing with the 3α-epimer of **30a**, as now H-3 had small vicinal couplings.

The ^{1}H NMR spectra of **38a** and **39a** (Experimental) were greatly broadened. Only a few signals could be assigned. Even at elevated temperature no well resolved spectra were obtained. All data agreed with the presence of germacradienes with an acetoxy group and a propenoic acid side chain. Heating at 180° gave the corresponding elemane derivatives **41a** and **42a** whose ^{1}H NMR spectra differed mainly in the shifts of H-1, H-2, H-3 and H-15. In the *E*-configurated isomer a small shielding effect of H-15 was visible. This assignment agrees with the observed couplings of H-3 in the spectrum of **38a** which indicated β-orientation of the acetoxy group if a model was inspected.

In the ^{1}H NMR spectrum of **40a** (Experimental) determined in a mixture of chloroform-*d*–benzene-d_6 all signals could be assigned by spin decoupling. The resulting sequence led to the proposed structure. The couplings of H-3 showed that most likely a 3β-acetoxy derivative was present, obviously formed by allylic oxidation of **38a**.

The aerial parts of *Calomeria amaranthoides* Vent. gave costic acid (**25**), its isomer **33** [13] and desoxyivangustin (**58**) [14] while the aerial parts of *Cassinia arcuata* R. Br. gave pinocembrin, its 3β-acetoxy derivative, eupatolide (**56**) [15] and the acids **33** and **34** [13]. From *Cassinia leptocephala* F. Muell. the guaianolides **44** and **45**, pseudoivalin (**52**) [16] and its 8-epimer **53** [17], carabrone (**55**) [18], tomentosin (**54**) [19] and **49** [20] were isolated.

The aerial parts of *Cratystylis microphylla* S. Moore gave, as another species [21], the triacetate **50** [21], the *cis*-lactone **46** [22], **47** [23], **48** [23] and 1α-Hydroxysteiractin-3,11(13)-dien-12,6β-olide (**57**) [22] as well as costic acid (**25**) and the derivatives **1** and **26–29** [21].

CONCLUSIONS

The chemistry of the two *Haeckeria* species is characterized by the accumulation of eremophilane acids which are relatively rare but some of them are reported also from representatives of the tribes Plucheae (*Tessaria* [5, 24], *Pluchea* [25, 26] and Inuleae s. str. [*Ondetia* [27]]).

Altogether only eight eremophilane acids are known, four from *Stevia* species [4], three from Inuleae and one from a *Flourensia* species [28]. Costic acid and its derivatives are much more widespread. However, it may be of chemotaxonomic interest that these acids are relatively common in several Australian Gnaphalieae (*Haeckeria*, *Cassinia* in part, *Calomeria*, *Helipterum* in part, *Apalochlamys*). Further investigations are necessary to get a clear picture of the chemotaxonomy of this complex group.

EXPERIMENTAL

The air-dried plant material was extracted with Et_2O–MeOH–petrol (1:1:1) at room temp. The obtained extracts were defatted with MeOH and separated by CC, TLC and HPLC as reported previously [29]. The extract of the aerial parts of *Haeckeria pholidota* (900 g, collected in South Eastern Australia in January 1989, voucher RMK 9731, deposited in the US National Herbarium, Washington) was separated by CC into four frs. The first fr. gave by TLC (petrol) 5 mg tridecapentaynene, the second 20 mg **51** and the third a complex mixture of sesquiterpene acids which were transformed to the methyl esters by addition of CH_2N_2. Repeated CC gave 3 frs (3/1–3/3). HPLC (MeOH–H_2O, 4:1, always RP 8 flow rate 3 ml min^{-1}) of 3/1 gave 50 mg **21a** (R_t 3.9 min), 10 mg **2a** (R_t 11.4 min), 10 mg **8a** (R_t 9.4 min) and two mixtures (R_t 5.3 and 10.6 min). TLC (Et_2O–petrol, 1:3) and HPLC (MeOH–H_2O, 3:1) of the first mixture gave 2 mg **9a** and 10 mg **3a**. TLC of the second mixture (Et_2O–petrol, 1:3) and HPLC (MeOH–H_2O, 4:1) gave 5 mg **5a** (R_t 12.3 min) and 5 mg **10a** (R_t 12.7 min). Repeated TLC of 3/2 gave 100 mg **21a** and 80 mg **12a**. HPLC of 3/3 (MeOH–H_2O, 4:1) gave 2 mg **18a** (R_t 1.5 min), 20 mg **20a** (R_t 2.3 min) and a mixture which gave by TLC (Et_2O–petrol, 1:3) and HPLC (MeOH–H_2O, 3:1) 3 mg **4a** (R_t 5.6 min). The last CC fraction also contain a complex mixture of acids which were transformed to the methyl esters. TLC (Et_2O–petrol, 1:1) gave 10 mg **21a** and

4 mixtures (4/1–4/4). HPLC of 4/1 (MeOH–H_2O, 4:1) gave 2 mixtures (4/1/1 and 4/1/2, R_t 3.3 and 3.9 min). TLC of 4/1/1 ($CHCl_3$–C_6H_6–Et_2O, 9:9:2) gave 2 mg **23a** (R_f 0.57) and 2 mg **15a** (R_f 0.35) and TLC of 4/1/2 (Et_2O–petrol, 1:1) gave 10 mg **24a** (R_f 0.62). HPLC (MeOH–H_2O, 4:1) of 4/2 gave 1 mg **17a** (R_t 2.5 min), 10 mg **12a** (R_t 6.0 min), 5 mg **21a** (R_t 6.3 min), 5 mg **22a** (R_t 4.0 min) and 1 mg **13a** (R_t 3.3 min) and HPLC (MeOH–H_2O, 4:1) of 4/3 2 mg **36a** (R_t 7.5 min) and two mixtures (4/3/1 and 4/3/2, R_t 2.7 and 4.2 min). TLC of 4/3/1 ($CHCl_3$–C_6H_6–Et_2O, 2:2:1) gave 1 mg **18a**, 1 mg **14a** and a mixture which afforded by HPLC (MeOH–H_2O, 13:7), 2 mg **16a** (R_t 8.3 min) and 1 mg **17a** (R_t 8.7 min). TLC of 4/3/2 ($CHCl_3$–C_6H_6–Et_2O, 9:9:2) gave 3 mg **20a** and 2 mg **19a** (R_f 0.50).

The extract of the aerial parts of *Haeckeria punctulata* (84 g, collected in South Australia in September 1989, voucher Nordenstam and Anderberg 1057, deposited in the Herbarium at Stockholm) gave by CC 2 polar fractions. The more polar one gave by TLC (Et_2O–MeOH, 99:1) 5 mg **44**, 30 mg **45** and 30 mg **35a**. From the first fr. the acids were sept by shaking with $NaHCO_3$ sol. which were transformed to the methyl esters with CH_2N_2. TLC (Et_2O–petrol, 1:1) gave 3 mg **26a** (R_f 0.40) and 3 mixtures. HPLC of the first one (MeOH–H_2O, 4:1) gave 5 mg **3a**, 2 mg **37a**, 6 mg **29a** (R_t 11.2 min), 5 mg **2a** (R_t 12.2 min), 2 mg **38a** (R_t 9.3 min), 2 mg **39a** (R_t 9.7 min), 2 mg **30a** (R_t 12.8 min) and 2 mg **36a** (R_t 9.5 min).

The second band gave by HPLC 2 mg **40a** (R_t 3.4 min), 2 mg **12a** (R_t 3.8 min), 17 mg **21a** (R_t 4.3 min), 3 mg **3a** (R_t 5.7 min) and 10 mg **43a**. HPLC of the last band gave 3 mg **21a** and 4 mg **31a**. Known compounds were identified by comparing the 400 MHz ^1H NMR spectra with those of authentic material and with lit. data. The results on the remaining species are summarized in Table 3.

3*β*-*Acetoxyeremophila*-9,11(13)-*dien*-12-*oic acid* (**2**). Isolated as its methylester **2a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1740, 1250 (OAc), 1725 (C=CCO_2R); MS *m/z* (rel. int.): 306.183 $[M]^+$ (1) (calc. for $C_{18}H_{26}O_4$: 306.183), 275 $[M-OMe]^+$ (14), 264 $[M-ketene]^+$ (46), 246 $[M-HOAc]^+$ (100), 231 $[246-Me]^+$ (76), 214 $[246-MeOH]^+$ (44), 199 $[214-Me]^+$ (62), 187 (60), 171 (58), 119 (74), 95 (76), 93 (82), 91 (61); $[\alpha]_D^{24}$ +19 ($CHCl_3$; *c* 0.45).

1*β*-*Acetoxy*-3-*oxo*-*eremophila*-9,11(13)-*dien*-12-*oic acid* (**4**). Isolated as its methylester **4a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1740 (OAc), 1725 (C=O, C=CCO_2R); MS *m/z* (rel. int.): 320 $[M]^+$ (0.2), 260.141 $[M-HOAc]^+$ (100) (calc. for $C_{16}H_{20}O_3$: 260.141), 228 $[260-MeOH]^+$ (32), 213 $[228-Me]^+$ (41), 204 $[260-O=C=CHMe]^+$ (96), 189 $[204-Me]^+$ (96), 172 $[204-MeOH]^+$ (92), 145 (84), 119 (56), 91 (61).

1*β*-*Acetoxy*-*eremophila*-9,11(13)-*dien*-12-*oic acid* (**5**). Isolated as its methylester **5a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1745 (OAc), 1725 (C=CCO_2R); MS *m/z* (rel. int.): 246.162 $[M-HOAc]^+$ (100) (calc. for $C_{16}H_{22}O_2$: 246.162), 231 $[246-Me]^+$ (56), 214 $[246-MeOH]^+$ (41), 186 $[214-CO]^+$ (56), 171 $[186-Me]^+$ (48), 160 (54), 145 (54), 119 (57), 91 (46).

3*β*-*Acetoxyeremophila*-1(10),11(13)-*dien*-12-*oic acid* (**8**). Isolated as its methylester **8a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1745 (OAc), 1730 (C=CCO_2R); MS *m/z* (rel. int.): 306.183 $[M]^+$ (2) (calc. for $C_{18}H_{26}O_4$: 306.183), 246 $[M-HOAc]^+$ (100), 214 $[246-MeOH]^+$ (23), 199 $[214-Me]^+$ (96), 171 (84), 143 (60), 119 (97), 105 (86), 91 (63), 79 (51).

3-*Oxo*-*eremophila*-1(10),11(13)-*dien*-12-*oic acid* (**9**). Isolated as its methylester **9a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1730 (C=O, C=CCO_2R); MS *m/z* (rel. int.): 262.157 $[M]^+$ (68) (calc. for $C_{16}H_{22}O_3$: 262.157), 247 $[M-Me]^+$ (17), 206 $[M-O=C=CHMe]^+$ (82), 174 $[206-MeOH]^+$ (100), 147 (51), 118 (64), 105 (64), 91 (62), 79 (83).

15-*Acetoxyeremophila*-1(10),11(13)-*dien*-12-*oic acid* (**10**). Isolated as its methylester **10a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1745 (OAc), 1725 (C=CCO_2R); MS *m/z* (rel. int.): 306.183 $[M]^+$ (9) (calc. for $C_{18}H_{26}O_4$: 306.183), 274 $[M-MeOH]^+$ (8), 246 $[M-HOAc]^+$ (100), 231 $[246-Me]^+$ (43), 214 $[246-MeOH]^+$ (40), 199 (42), 187 (52), 171 (56), 145 (60), 119 (63), 105 (63), 91 (61), 79 (47).

2*β*-*Acetoxy*-3-*oxo*-*eremophila*-1(10),11(13)-*dien*-12-*oic acid* (**12**). Isolated as its methylester **12a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1745 (OAc), 1730 (C=CCO_2R, C=O); MS *m/z* (rel. int.): 320.162 $[M]^+$ (11) (calc. for $C_{18}H_{24}O_5$: 320.162), 278 $[M-ketene]^+$ (100), 246 $[278-MeOH]^+$ (24), 231 $[246-Me]^+$ (22), 121 (30), 119 (28), 105 (34), 91 (37), 82 (41); CD (MeOH): $\Delta\varepsilon_{285}$ −1.85.

2-*Acetoxy*-10*β*-*hydroperoxy*-3-*oxo*-*eremophila*-1,11(13)-*dien*-12-*oic acid* (**13**). Isolated as its methylester **13a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3600 (OH), 1780 (C=COAc), 1730 (C=CCO_2R), 1705 (C=CC=O); MS *m/z* (rel. int.): 319 $[M-O_2H]^+$ (2), 277 $[319-ketene]^+$ (80), 245 $[277-MeOH]^+$ (28), 55 (100). Addition of $P(C_6H_5)_3$ in $CDCl_3$ gave **16a**, identical with the ester of the natural carbinol.

2-*Acetoxy*-10*β*-*hydroxy*-3-*oxo*-*eremophila*-1,11(13)-*dien*-12-*oic acid* (**14**). Isolated as its methylester **14a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3620 (OH), 1780 (C=COAc), 1730 (C=CCO_2R), 1700 (C=CC=O); MS *m/z* (rel. int.): 294.147 $[M]^+$ (100) (calc. for $C_{16}H_{22}O_5$: 294.147), 276 $[M-H_2O]^+$ (14), 262 $[M-MeOH]^+$ (26), 234 $[262-CO]^+$ (23), 207 (57), 177 (24), 167 (26), 154 (96), 126 (57), 109 (44).

10*β*-*Hydroperoxy*-3-*oxo*-*eremophila*-1,11(13)-*dien*-12-*oic acid* (**15**). Isolated as its methylester **15a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3600 (OH), 1680 (C=CC=O); MS *m/z* (rel. int.): 294.147 $[M]^+$ (16) (calc. for $C_{16}H_{22}O_5$: 294.147), 277 $[M-OH]^+$ (72), 261 $[M-O_2H]^+$ (51), 245 $[277-MeOH]^+$ (26), 229 $[261-MeOH]^+$ (32), 109 (58), 83 (64), 69 (86), 55 (100); CD (MeOH): $\Delta\varepsilon_{322}$ −0.27. Addition of $P(C_6H_5)_3$ in $CDCl_3$ gave the carbinol **16a**, identical with the ester of the natural compound.

10*β*-*Hydroxy*-3-*oxo*-*eremophila*-1,11(13)-*dien*-12-*oic acid* (**16**). Isolated as its methylester **16a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3600 (OH), 1730 (C=CCO_2R), 1690 (C=CC=O); MS *m/z* (rel. int.): 278.152 $[M]^+$ (40) (calc. for $C_{16}H_{22}O_4$: 278.152), 260 $[M-H_2O]^+$ (14), 246 [M

Table 3. Compounds isolated from further species

Species	Aerial parts (g)	Compounds
Cassinia arcutata R. Br. (leg. Nordenstam and Anderberg)	50	50 mg pinocembrin, 10 mg 3*β*-acetoxypinocembrin, 30 mg **56**, 10 mg **33**, 50 mg **34**
Cassinia leptocephala F. Muell. (voucher Anderberg and Anderberg 7160)	39	5 mg **44**, 30 mg **45**, 2 mg **53**, 5 mg **52**, 10 mg **54**, 5 mg **55**, 2 mg **49**
Cratystylis microphylla S. Moore (voucher Nordenstam and Anderberg 613)	130	150 mg **46**, 5 mg **57**, 5 mg **50**, 5 mg **47**, 10 mg **48**, 900 mg **25**, 80 mg **1**, 500 mg **26**, 50 mg **27**, 200 mg **28**, 10 mg **29**
Calomeria amaranthoides Vent. (voucher Nordenstam and Anderberg 1331)	68	40 mg **58**, 60 mg **25**, 500 mg **33**

MeOH]$^+$ (64), 219 (76), 177 (72), 137 (100), 123 (90), 107 (80), 91 (90), 69 (88).

10α-*Hydroxy*-3-*oxo*-*eremophila*-1,11(13)-*dien*-12-*oic acid* (**17**). Isolated as its methylester **17a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3600 (OH), 1730 (C=CCO_2R), 1685 (C=CC=O); MS *m/z* (rel. int.): 278.152 [M]$^+$ (6) (calc. for $C_{16}H_{22}O_4$: 278.152), 246 [M−MeOH]$^+$ (4), 207 (11), 111 (24), 97 (42), 83 (51), 69 (70), 57 (100).

3α-*Hydroxy*-2-*oxo*-*eremophila*-1(10),11(13)-*dien*-12-*oic acid* (**18**). Isolated as its methylester **18a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3500 (OH, hydrogen bonded), 1730 (C=CCO_2R), 1680, 1630 (C=CC=O); MS *m/z* (rel. int.): 278.152 [M]$^+$ (16) (calc. for $C_{16}H_{22}O_4$: 278.152), 247 [M−MeOH]$^+$ (6), 220 [M−HOCH=CHMe]$^+$ (100), 188 [220−MeOH]$^+$ (12), 165 (62), 108 (54); CD (MeOH): $\Delta\varepsilon_{345}$ −0.1.

3β-*Acetoxy*-2-*oxo*-*eremophila*-1(10),11(13)-*dien*-12-*oic acid* (**19**). Isolated as its methylester **19a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1745 (OAc), 1730 (C=CCO_2R), 1680 (C=CC=O); MS *m/z* (rel. int.): 320.162 [M]$^+$ (18) (calc. for $C_{18}H_{24}O_5$: 320.162), 289 [M−OMe]$^+$ (7), 260 [M−HOAc]$^+$ (11), 220 [M−AcOCH=CMe]$^+$ (100), 188 [220−MeOH]$^+$ (32), 165 (96), 149 (95), 108 (94); CD (MeOH): $\Delta\varepsilon_{325}$ −0.46.

3-*Hydroxy*-2-*oxo*-*eremophila*-1(10),3,11(13)-*trien*-12-*oic acid* (**20**). Isolated as its methylester **20a**; crystals, mp 107°; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3420 (OH), 1725 (C=CCO_2R), 1650 (C=CCOC=C); MS *m/z* (rel. int.): 276.136 [M]$^+$ (87) (calc. for $C_{16}H_{20}O_4$: 276.126), 261 [M−Me]$^+$ (14), 244 [M−MeOH]$^+$ (22), 220 [M−HOC≡CMe]$^+$ (80), 201 (46), 188 (51), 165 (61), 149 (77), 121 (74), 91 (60), 69 (100); ^{13}C NMR ($CDCl_3$, C-1–C-15): δ122.3, 180.2, 134.4, 144.0, 43.9, 29.4, 33.9, 29.3, 40.3, 171.1, 143.3, 167.5, 123.1, 26.1, 11.1; OMe: 51.8; CD (MeOH): $\Delta\varepsilon_{306}$ +0.61.

3-*Oxo*-*eremophila*-1,9,11(13)-*trien*-12-*oic acid* (**21**). Isolated as its methylester **21a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1725 (C=CCO_2R), 1685 (C=CC=O); MS *m/z* (rel. int.): 260.141 [M]$^+$ (77) (calc. for $C_{16}H_{20}O_3$: 260.141), 245 [M−Me]$^+$ (25), 228 [M−MeOH]$^+$ (58), 213 [228−Me]$^+$ (24), 185 [213−CO]$^+$ (30), 174 [M−CH_2=CH–CO_2Me]$^+$ (100), 159 [174−Me]$^+$ (78), 135 (44), 105 (31), 91 (33); ^{13}C NMR ($CDCl_3$, C-1–C-15): δ145.5, 125.4, 201.5, 50.8, 41.1, 31.3, 33.2, 39.9, 130.8, 142.3, 144.0, 167.3, 123.6, 22.6, 7.4; OMe: 51.9; CD (MeOH): $\Delta\varepsilon_{330}$ −1.56. To 10 mg **21a** in 3 ml $CHCl_3$, 30 mg *m*-chloroperbenzoic acid and 20 mg $NaHCO_3$ was added. After stirring for 3 hr TLC after usual work-up gave 9 mg **22a** and 1 mg **23a**. The epoxides were identical with the methylester of the natural compounds.

9β,10β-*Epoxy*-3-*oxo*-*eremophila*-1,11(13)-*dien*-12-*oic acid* (**22**). Isolated as its methylester **22a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1730 (C=CCO_2R), 1680 (C=CC=O); MS *m/z* (rel. int.): 276.136 [M]$^+$ (8) (calc. for $C_{16}H_{26}O_4$: 276.136), 261 [M−Me]$^+$ (4), 220 (22), 135 (46), 123 (100), 122 (81); ^{13}C NMR ($CDCl_3$, C-1–C-15): δ148.7, 131.7, 200.7, 47.2, 41.0, 29.0, 29.7, 35.5, 60.6, 63.0, 143.3, 167.2, 123.9, 18.8, 7.2; OMe: 52.0; CD (MeOH): $\Delta\varepsilon_{325}$ −0.65.

9α,10α-*Epoxy*-3-*oxo*-*eremophila*-1,11(13)-*dien*-12-*oic acid* (**23**). Isolated as its methylester **23a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1730 (C=CCO_2R), 1690 (C=CC=O); MS *m/z* (rel. int.): 276.136 [M]$^+$ (4) (calc. for $C_{16}H_{20}O_4$: 276.136), 245 [M−OMe]$^+$ (7), 217 [25−CO]$^+$ (3), 149 (40), 135 (35), 123 (100).

3,4-seco-4-*Oxo*-3-nor-*eremophila*-1(10),11(13)-*dien*-2,12-*dioic acid* (**24**). Isolated as its dimethylester **24a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1730 (C=CCO_2R, CO); MS *m/z* (rel. int.): 294.147 [M]$^+$ (2) (calc. for $C_{16}H_{22}O_5$: 294.147), 263 [M−OMe]$^+$ (22), 252 [M−ketene]$^+$ (66), 220 [252−MeOH]$^+$ (100), 188 [220−MeOH]$^+$ (73), 165 (88), 133 (56), 108 (76), 91 (51); ^{13}C NMR ($CDCl_3$, C-1, C-2 and C-4–C-15): δ116.1, 167.0, 208.4, 54.2, 28.9, 33.1, 33.6, 39.1, 159.0, 144.4, 167.1, 123.5, 23.9, 25.5; OMe: 51.7, 51.2; CD (MeOH): $\Delta\varepsilon_{296}$ +1.2.

3β-*Acetoxy*-*eudesma*-4(15),11(13)-*dien*-12-*oic acid* (**30**). Isolated as its methylester **30a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1745, 1250 (OAc), 1725 (C=CCO_2R); MS *m/z* (rel. int.): 306.183 [M]$^+$ (1) (calc. for $C_{18}H_{26}O_4$: 306.183), 246 [M−HOAc]$^+$ (100), 231 [246−Me]$^+$ (80), 214 [246−MeOH]$^+$ (44), 199 (66), 171 (48), 159 (32), 145 (42), 131 (34), 119 (74), 105 (56), 93 (82); ^{1}H NMR ($CDCl_3$): δ5.16 (*br dd*, H-3), 1.91 (*br d*, H-5), 1.64 (*br d*, H-6α), 1.34 (*q*, H-6β), 2.53 (*br tt*, H-7), 1.64 and 1.45 (*m*, H-8), 6.16 (*br s*, H-13), 5.57 (*br s*, H-13′), 0.77 (*s*, H-14), 4.87 and 4.56 (*br s*, H-15), 3.76 (*s*, OMe), 2.12 (*s*, OAc); *J* [Hz]: 2, 3 = 5.5; 2′, 3 = 11.5; 5, 6β = 6α, 6β = 6β, 7 = 7, 8β ∼ 12; 6α, 7 = 7, 8α = 3.

3α-*Acetoxy*-*eudesma*-4(15),11(13)-*dien*-12-*oic acid* (**31**). Isolated as its methylester **31a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1745, 1250 (OAc), 1725 (C=CCO_2R); MS *m/z* (rel. int.): 246.162 [M−HOAc]$^+$ (100) (calc. for $C_{16}H_{22}O_2$: 246.162), 231 (52), 214 (23), 199 (30), 187 (32), 95 (63), 81 (56), 69 (82); ^{1}H NMR ($CDCl_3$): δ5.34 (*br t*, H-3), 2.61 (*br tt*, H-7), 6.17 and 5.58 (*br s*, H-13), 0.76 (*s*, H-14), 5.07 and 4.67 (*t*, H-15), 3.77 (*s*, OMe), 2.06 (*s*, OAc); *J* [Hz]: 2, 3 = 2′, 3 ∼ 2.5; 5, 15 = 3, 15 = 1; 6, 7 = 7, 8 = 11; 6′, 7 = 7, 8′ ∼ 3.

3β-*Acetoxy*-4α-*hydroxyeudesm*-11(13)-*en*-12-*oic acid* (**35**). Isolated as its methylester **35a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3600 (OH), 1740, 1250 (OAc), 1725 (C=CCO_2R); MS *m/z* (rel. int.): 324.194 [M]$^+$ (20) (calc. for $C_{18}H_{28}O_5$: 324.194), 309 (7), 282 (1), 264 (19), 249 (23), 246 (15), 223 (100), 191 (55), 149 (46); ^{1}H NMR ($CDCl_3$): δ4.67 (*dd*, H-3), 2.50 (*tt*, H-7), 6.14 (*d*, H-13), 5.56 (*t*, H-13′), 0.94 (*s*, H-14), 1.11 (*s*, H-15), 3.76 (*s*, OMe), 2.10 (*s*, OAc); *J* [Hz]: 2, 3 = 12; 2′, 3 = 5; 6β, 7 = 7, 8β = 12; 6α, 7 = 7, 8α = 3; 7, 13′ = 13, 13′ ∼ 1.

3α-*Acetoxy*-4α-*hydroxyeudesm*-11(13)-*en*-12-*oic acid* (**36**). MS *m/z* (rel. int.): 310.178 [M]$^+$ (3) (calc. for $C_{17}H_{26}O_5$: 310.178), 293 [M−OH]$^+$ (11), 250 [M−HOAc]$^+$ (16), 233 [293−HOAc]$^+$ (33), 191 (36), 148 (60), 92 (78), 71 (94), 55 (100); purified as its methylester **36a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3600 (OH), 1745, 1250 (OAc), 1725 (C=CCO_2R); MS *m/z* (rel. int.): 324.194 [M]$^+$ (15) (calc. for $C_{18}H_{28}O_5$: 324.194), 309 [M−Me]$^+$ (6), 293 [M−OMe]$^+$ (11), 282 [M−ketene]$^+$ (22), 264 [M−HOAc]$^+$ (37), 249 [264−Me]$^+$ (43), 246 [264−H_2O]$^+$ (42), 223 [309−$C_4H_6O_2$]$^+$ (100), 191 (88), 149 (84), 119 (64), 105 (67), 93 (68), 81 (66); ^{1}H NMR ($CDCl_3$): δ1.38 (*m*, H-1α), 1.18 (*m*, H-1β), 1.84 (*m*, H-2), 4.75 (*t*, H-3), 1.62 (*dd*, H-5), 1.94 (*ddt*, H-6α), 1.23 (*q*, H-6β), 2.52 (*br tt*, H-7), 1.63 (*br d*, H-8α), 1.45 (*m*, H-8β, H-9), 6.13 (*d*, H-13), 5.56 (*t*, H-13′), 0.93 (*s*, H-14), 1.13 (*s*, H-15), 3.75 (*s*, OMe), 2.12 (*s*, OAc); *J* [Hz]: 2, 3 = 2′, 3 = 2.5; 5, 6β = 6α, 6β = 6β, 7 = 7, 8β ∼ 12; 5, 6α = 2.5; 6α, 7 = 7, 8α = 3.5; 6α, 8α = 2.5; 8α, 8β = 13; 7, 13′ = 13, 13′ = 1; ^{13}C NMR ($CDCl_3$, C-1–C-15): δ34.1, 27.3, 77.6, 71.7, 49.6, 23.7, 40.4, 26.0, 44.2, 34.3, 145.5, 167.8, 122.5, 18.4, 21.0; OMe: 51.8; OAc: 21.4, 170.6; $[\alpha]_D^{24°}$ −53 ($CHCl_3$; *c* 2.07).

3α-*Acetoxygermacra*-1(10)E,4E,11(13)-*trien*-12-*oic acid* (**38**). Isolated as its methylester **38a**; MS *m/z* (rel. int.): 246.162 [M−HOAc]$^+$ (18) (calc. for $C_{16}H_{22}O_2$: 246.162); ^{1}H NMR ($CDCl_3$): δ5.31 (*m*, H-1), 5.39 (*m*, H-3), 5.18 (*m*, H-5), 2.81 (*m*, H-7), 6.14 and 5.55 (*br s*, H-13), 1.56 (*br s*, H-14), 1.62 (*br s*, H-15), 2.07 (*br s*, OAc), 3.77 (*br s*, OMe). Heating of **38a** in 0.5 ml C_6H_6 in a sealed tube for 1 hr at 180° gave after HPLC (MeOH–H_2O, 4:1) **41a** (R_t 13.4 min); MS *m/z* (rel. int.): 306.183 [M]$^+$ (3.5) (calc. for $C_{18}H_{26}O_4$: 306.183), 264 [M−ketene]$^+$ (12), 246 [M−HOAc]$^+$ (48), 231 [246−Mc]$^+$ (18), 181 (51), 149 (60), 126 (100), 81 (78); ^{1}H NMR ($CDCl_3$): δ5.79 (*dd*, H-1), 4.92 (*dd*, H-2c), 4.91 (*dd*, H-2t), 6.83 (*q*, H-3), 2.58 (*m*, H-7), 6.16 (*d*, H-13), 5.57 (*t*, H-13′), 1.03 (*s*, H-14), 1.64 (*d*, H-15), 3.76 (*s*, OMe), 2.15 (*s*, OAc); *J* [Hz]: 1, 2c = 11; 1, 2t = 17; 2c, 2t = 3, 5 = 3, 15 ∼ 1.5; 7, 13′ = 13, 13′ ∼ 1.

3β-*Acetoxygermacra*-1(10)E,4E,11(13)-*trien*-12-*oic acid* (**39**). Isolated as its methylester **39a**; MS *m/z* (rel. int.): 306.183 [M]$^+$ (3) (calc. for $C_{18}H_{26}O_4$: 306.183); ^{1}H NMR ($CDCl_3$): δ4.93 (*br dd*, H-1), 5.12 (*br dd*, H-3), 4.82 (*br t*, H-5), 6.10 and 5.56 (*br s*, H-13), 1.45 (*br s*, H-14), 1.52 (*br s*, H-15), 3.76 (*s*, OMe), 2.08 (*s*, OAc);

J[Hz]: 1, 2 = 12; 1, 2′ = 4; 2, 3 = 10; 2, 3′ = 5; 5, 6 ~ 7. Heating of **39a** (see above) gave after HPLC (MeOH–H_2O, 4:1) **42** (R_t 15.0 min); MS m/z (rel. int.): 306.183 $[M]^+$ (2) (calc. for $C_{18}H_{26}O_4$: 306.183), 246 $[M-HOAc]^+$ (84), 231 $[246-Me]^+$ (44), 187 (40), 149 (64), 81 (100); ^1H NMR ($CDCl_3$): δ5.79 (*dd*, H-1), 4.91 (*dd*, H-2c), 4.91 (*dd*, H-2t), 6.83 (*q*, H-3), 2.58 (*m*, H-7), 6.16 (*d*, H-13), 5.57 (*t*, H-13′), 1.03 (*s*, H-14), 1.64 (*d*, H-15), 3.76 (*s*, OMe), 2.12 (*s*, OAc); J[Hz]: 1, 2c = 11; 1, 2t = 17; 2c, 2t = 3, 5 = 3, 15 ~ 1.5; 7, 13′ = 13, 13′ ~ 1.

3β-Acetoxy-1-oxo-germacra-5E,10(14),11(13)-trien-12-oic acid (**40**). Isolated as its methylester **40a**; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1750 (OAc), 1730 (C=CCO$_2$R), 1680 (C=CC=O); MS m/z (rel. int.): 320.162 $[M]^+$ (1) (calc. for $C_{18}H_{24}O_5$: 320.162), 278 $[M-ketene]^+$ (6), 260 $[M-HOAc]^+$ (25), 246 $[278-MeOH]^+$ (57), 231 $[246-Me]^+$ (20), 119 (56), 105 (66), 91 (88), 55 (100); ^1H NMR ($CDCl_3/C_6H_6$): δ2.58 (*dd*, H-2α), 3.18 (*t*, H-2β), 5.32 (*dd*, H-3), 5.40 (*br t*, H-5), 1.77 and 2.02 (*m*, H-6), 2.48 (*m*, H-7), 1.52 and 1.40 (*m*, H-8), 2.63 (*br dt*, H-9), 2.02 (*m*, H-9′), 6.03 and 5.34 (*br s*, H-13), 5.62 and 5.56 (*br s*, H-14), 3.55 (*s*, OMe), 1.86 (*s*, OAc); J [Hz]: 2α, 2β = 2β, 3 = 11; 2α, 3 = 5.5; 5, 6 = 5, 6′ = 7.5; 8, 9 = 8′, 9 = 4; 9, 9′ = 14.

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