graphed over Si gel plates eluted with $CHCl_3$ as eluent. After repeated crystallization from MeOH, **3** (100 mg) was obtained, mp 226–229°; $[\alpha]_D^{23}$ +41° (*c* 0.86; $CHCl_3$); IR ν_{max}^{KBr} cm^{-1}: 3300 (hydroxyl), 1750 (γ-lactone), 1675 (cyclopentenone), 1632, 1618 (olefinic bonds), 1418, 1390, 1325, 1290, 1231, 1205, 1100, 1085, 1045, 1010, 865, 765, 684. UV λ_{max}^{EtOH} nm (log ϵ): 257 (4.18) (cyclopentenone chromophore), 235 (4.02) (α,β-unsaturated lactone). ^1H NMR (90 MHz, $CDCl_3$): see Table 1. EIMS (direct inlet) 75 eV, *m/z* (rel. int.): 260 (M^+, 100), 245 (6), 242 (13), 227 (8), 214 (8), 199 (23), 197 (19), 186 (14), 185 (13), 171 (14), 143 (11), 135 (66), 126 (60), 107 (40), 105 (16), 98 (16), 91 (65), 77 (28), 69 (81), 65 (30), 51 (30), 44 (39). (Found: C, 68.94; H, 6.30. $C_{15}H_{16}O_4$ requires: C, 69.21; H, 6.20%.)

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ISOLATION AND STRUCTURE OF STEPHALIC ACID, A NEW CLERODANE DITERPENE FROM *STEVIA POLYCEPHALA**

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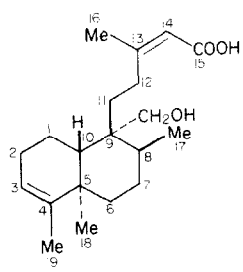
Key Word Index—*Stevia polycephala*; Compositae; stephalic acid; clerodane derivatives; diterpenes.

Abstract—From the methanolic extract of *Stevia polycephala* a new clerodane-type diterpene, stephalic acid, was isolated. The structure and stereochemistry were determined by a combination of spectral data and single-crystal X-ray analysis.

The *Stevia* genus is one of the largest found in Mexico [1]. Sesquiterpene lactones [2–4] and diterpenes [5] have been isolated from the non-polar or chloroform fractions of Mexican *Stevia* species. Isohumelene and new α-longipinene derivatives have been isolated from *Stevia polycephala* [6]. In our continuing search for new natural products from *Stevia* species, we examined the polar fraction of the methanolic extract of *S. polycephala* collected in the state of Tlaxcala, Mexico, and have isolated a new diterpene, stephalic acid (**1**), which possesses the clerodane carbon skeleton.



1

Fractionation of the methanol extract of *S. polycephala* with ethyl acetate and chromatographic separation employing Si gel provided a new diter-

*Contribution No. 563.

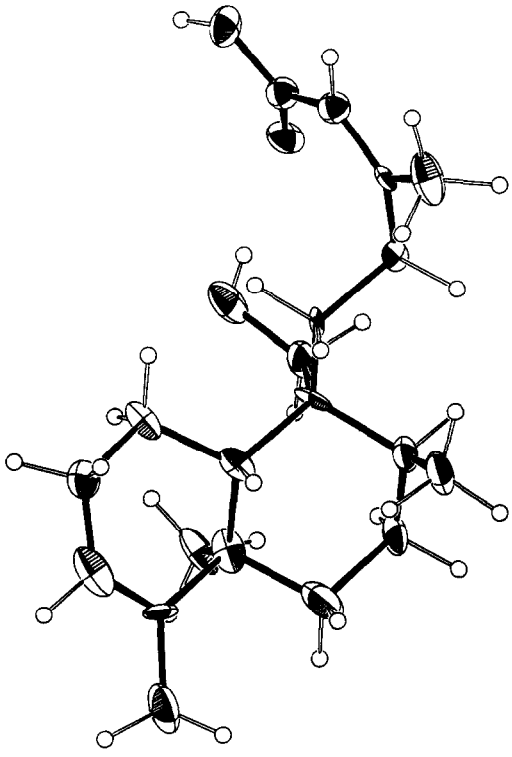
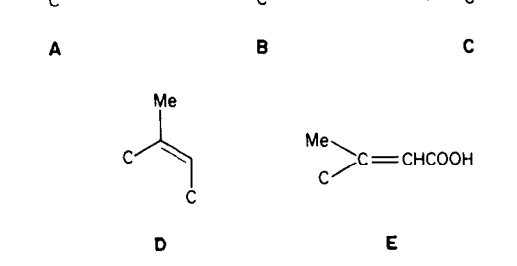


Fig. 1. ORTEP view of stephalic acid.

pene. Stephalic acid (**1**), $C_{20}H_{32}O_3$, M^+ at *m/z* 320, was obtained as a crystalline solid, mp 183.5–185.0°, $[\alpha]_D^{25}$ +217.0° (*c* 1.0, $CHCl_3$). The IR spectrum ($CDCl_3$) of **1** exhibited a three-proton singlet at δ 1.93 and a one-proton singlet at 1.73 which together with IR ($CDCl_3$) bands at 3615, 3585, and 2300–3300 cm^{-1} and a UV (MeOH) absorption at λ_{max} 202 nm (ε 9600) suggested the presence of a β-alkyl, β-methyl acrylic acid unit.

The presence of a two-proton AB quartet centered at δ 4.00 in the ^1H NMR spectrum, together with an absorption band at 3420 cm^{-1} in the IR spectrum, indicated the presence of a hydroxymethyl group attached to a quaternary carbon. Further examination of the ^1H NMR spectrum revealed the presence of a secondary methyl group (δ 1.00), a methyl group (1.04) attached to a quaternary carbon, and an olefinic methyl group (1.59) of which the olefin was part of a six-membered ring. The above data led to five partial structures **A–E**.



Unambiguous structural assignment was obtained by carrying out a single-crystal X-ray analysis of **1** (Fig. 1). Stephalic acid crystallizes in the monoclinic space group $P2_1$, with $a = 8.51$ (2), $b = 7.52$ (2), $c = 14.65$ (4) Å, $b = 100.86$ (11), $V = 920.5$ Å^3, giving $D_{calc} = 1.156$ g/cm^3 for $Z = 2$. All measurements were at −165°. A total of 2290 unique intensities were collected using a θ–2θ continuous scan technique with the following values: scan rate = 2.5/min, 10-sec stationary scans at extremes of scan, 2.0° scan width. All data were collected for $+h, +k, \pm l$ in the range $6 \leq 2\theta \leq 45$ using Mo K_α radiation ($\lambda = 0.71069$ Å). The structure was solved by direct methods (MULTAN) and refined by full-matrix techniques. All atoms were located and refined, with the thermal parameters of the hydrogen atoms fixed. Final residuals were $R(F) = 0.077$ and $R_w(F) = 0.059$ [7]. No attempt was made to assign the absolute configuration.

EXPERIMENTAL

Isolation of stephalic acid. Stevia polycephala Bertol was collected in the state of Tlaxcala, Mexico, during Sept. 1977. The dried whole plant (2 kg) was extracted with 15.0 l. of warm MeOH. The extract was filtered, concentrated to 2.0 l., and washed in a liquid–liquid extractor with 1.0 l. of hexane which was discarded. The MeOH extract was evaporated to dryness under red. pres. providing 110 g of a syrupy green oil. The part soluble in warm EtOAc (80 g) was chromatographed on 1.0 kg of Si gel (packed in EtOAc–C_6H_6, 1:9). The column was successively eluted, taking fractions of *ca.* 500 ml: fractions 1–5 (EtOAc–C_6H_6, 1:9), fractions 6–10 (EtOAc–C_6H_6, 3:7), fractions 11–20 (EtOAc–C_6H_6, 6:4), fractions 21–26 (EtOAc), fractions 27–37 (EtOAc–MeOH, 9:1).

Fractions 18–25 which exhibited one major spot on TLC analysis were combined and rechromatographed on Si gel. The EtOAc–C_6H_6 (3:2) fractions were combined and the crude material obtained upon evaporation of the solvent was submitted to prep. TLC on Si gel (C_6H_6–EtOAc, 4:1, three developments). This produced 40 mg of a gum which upon crystallization from EtOAc–hexane, provided pure stephalic acid, mp 183.5–185.0°: $[\alpha]_D^{25}$ +217.0° (*c* 1.0, $CHCl_3$); UV λ_{max}^{MeOH} *nm:* 202 (ε 9600); IR $\nu_{max}^{CHCl_3}$ *cm*$^{-1}$: 3420, 3300–2300, 1685, 1651; ^1H NMR (220 MHz, $CDCl_3$): δ 1.00 (*d*, 2H, *J* = 7 Hz, H-17), 1.14 (*s*, 3H, H-18), 1.59 (*br s*, 3H, H-19), 1.93 (*s*, 3H, H-16), 3.23 (*br t*, 1H, *J* = 10 Hz), 4.00 (*AB q*, 2H, *J* = 12 Hz, $\Delta\nu_{AB}$ = 12 Hz, CH_2OH), 5.20 (*br s*, 1H, H-3), 5.73 (*s*, 1H, H-14); MS *m/z* (*rel. int.*): 320 [*M*]$^+$ (5), 302 $[M-H_2O]^+$ (18), 284 $[M-2H_2O)^+$ (15), 202(14), 191(13), 184 (35), 161 (14), 147 (22), 133 (23), 121 (34), 120 (30), 119 (35), 109 (28), 107 (48), 100 (31), 95 (100), 93 (36), 91 (28), 80 (42), 69 (26), 67 (25), 55 (40), 41 (41). (Found: C, 74.81; H, 9.96. $C_{20}H_{32}O_3$ requires: C, 74.96; H, 10.06%.)

Complete X-ray crystallographic details are available in microfiche form from the Indiana University Chemistry Library. Request M.S.C. Report 8040 when ordering.

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A NEW SECO-LABDANE DERIVATIVE FROM *ATHRIXIA ELATA**

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Key Word Index—*Athrixia elata*; Compositae; diterpenes; seco-labdane derivative; triterpenes; 2β-hydroxyerythrodiol.

Abstract—*Athrixia elata* afforded, in addition to known compounds, a new seco-labdane derivative and a new triterpene.

From the mainly South African genus *Athrixia* (tribe Inuleae, subtribe Athrixiinae) some species have been investigated chemically [1]. In addition to triterpenes and thymol derivatives some diterpenes related to kaurene were present. We have now studied the constituents of *A. elata* Sond. The roots afforded the thymol derivatives **1–3**, friedelin, dammadienone and the corresponding acetate, *ent*-kaurenic acid (**6**) and the 9, 11-dehydro derivative **7** and 4-formylathrixinone (**8**) [1]. The aerial parts gave squalene, germacrene D, caryophyllene, α-humulene, the cinnamates **4** and **5** [2], the triterpene **9** and the seco-labdane derivative **10**. The structure of **9** followed from the molecular formula and the ^{1}H NMR spectrum (Table 1), which was close to that of erythrodiol [3]. The position and the stereochemistry of the additional hydroxyl group followed from the couplings of H-2 and from double resonance experiments. Ac-

Table 1. ^{1}H NMR spectral data of compound **9** (400 MHz, $CDCl_3$, TMS as int. standard)

H-1	2.07 *dd*	H-23′	3.56 *d*
H-1′	2.14 *dd*	H-24	1.01 *s*
H-2	4.09 *ddd*	H-25	1.03 *s*
H-3	3.23 *d*	H-26	0.96 *s*
H-9	1.49 *ddd*	H-27	1.16 *s*
H-11	1.87 *ddd*	H-28	1.26 *s*
H-11′	1.99 *ddd*	H-29	0.87 *s*
H-12	5.21 *dd*	H-30	0.89 *s*
H-23	3.21 *d*		

J(Hz): 1, 1′ = 12.5; 1′, 2 = 2.5; 2, 3 = 5; 9, 11 = 6.5; 9, 11′ = 12; 11, 11′ = 17; 11, 12 = 11′, 12 = 3; 12, 12′ = 11.

Table 2. ^{1}H NMR spectral data of compound **10** (400 MHz, TMS as int. standard)

	$CDCl_3$	C_6H_6
H-5	2.03 *t*	2.06 *t*
H-6	2.43 *d*	2.33 *d*
H-9	2.66 *dd*	2.63 *dd*
H-11	2.39 *ddd*	2.46 *ddd*
H-11′	2.61 *ddd*	2.75 *ddd*
H-12	5.23 *dd*(*br*)	5.51 *dd*(*br*)
H-14	6.30 *dd*	6.51 *dd*
H-15	4.94 *d*	5.01 *d*
H-15′	5.09 *d*	5.17 *d*
H-16	1.72 *s*(*br*)	1.84 *s*(*br*)
H-17	2.12 *s*	1.90 *s*
H-18	0.98 *s*	0.74 *s*
H-19	0.99 *s*	0.73 *s*
H-20	0.95 *s*	0.92 *s*

J (Hz): 5, 6 = 4.5; 9, 11 = 2; 9, 11′ = 11.5; 11, 11′ = 13; 11, 12 = 5; 11′, 12 = 8.5; 14, 15 = 11; 14, 15′ = 17.

*Part 435 in the series "Naturally Occurring Terpene Derivatives". For Part 434 see Bohlmann, F. and Gupta, R. K. (1982) *Phytochemistry* **21** (in press).