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MONOTERPENE DERIVATIVES FROM THE ESSENTIAL OIL OF *ARISTOLOCHIA LONGA*

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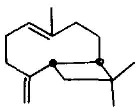
Key Word Index—*Aristolochia longa*; Aristolochiaceae; essential oil; new pinane derivatives.

Abstract—Two new pinane monoterpenes, pin-2-en-8-ol and its acetyl derivative, and also β-caryophyllene, caryophyllene oxide, linalool and bornyl acetate were isolated from the essential oil of the aerial parts of *Aristolochia longa*. From the volatile fraction of the underground part of the plant only the tricyclic sesquiterpenes calarene, maaliol and 1(10)-aristolen-2-one were isolated.

INTRODUCTION

The pharmacological properties of the aristolochic acids [1, 2] have motivated studies on several species of the genus Aristolochia where these acids accumulate, principally in the roots. However, references in the literature to other, mainly volatile, compounds, are scarce [3–10].

As part of an investigation on *A. longa*, we have examined the components of the steam distillate of the hexane extract of the roots and aerial parts of the plant. Only tricyclic sesquiterpenes, with the maaliane and aristolane skeletons, were isolated from the roots, while from the aerial parts it was possible to isolate sesquiterpenes with a caryophyllene skeleton and also monoterpenes. Two of these latter compounds with a pinane skeleton have been recently isolated, together with ferulagol [3, 2 (10)-pinadien-8-ol], from *Ferulago capillifolia* (B. Jimenez, personal communication). These are the first cases to be described in the literature of pinanes functionalized at C-8.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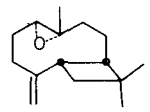
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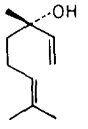
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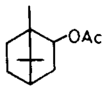
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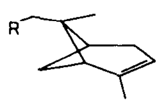
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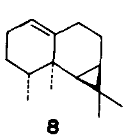
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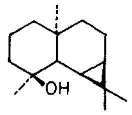
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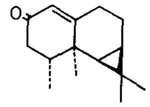
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RESULTS AND DISCUSSION

The essential oils of the aerial parts and the roots were separated by steam distillation of the corresponding hexane extracts. The essential oil of the aerial parts yielded two sesquiterpenes, β-caryophyllene (**1**) and caryophyllene oxide (**2**) and four monoterpenes, linalool (**3**), bornyl acetate (**4**), and compounds **5** and **6**. Of these, the first four, identified by comparison of their physical and spectroscopic properties with those described in the literature [11] or with authentic samples, are described for the first time in the genus *Aristolochia*. Borneol has been described previously in *A. zenkeri* [10].

The IR spectrum of **5** corresponded to the acetyl derivative of an unsaturated alcohol (1750, 1665 and 1245 cm^{-1}) and its ^{1}H NMR spectrum gave signals characteristic of the following partial structures: CH=C, C–CH$_2$OAc, Me–COO, Me–C=C and Me–C. In the mass spectrum, the peak at *m/z* 134 corresponded to the [M − 60]$^+$ fragment, showing that **5** had a molecular weight of 194, corresponding to the formula $C_{12}H_{18}O_2$ which is the acetate of a bicyclic monoterpene alcohol with a double bond.

Comparing the ^{1}H NMR spectra of α-pinene (**7**) [12] with that of **5** (Table 1) the following analogies were observed. The olefinic hydrogen, the methyl on the double bond, the C-9 methyl and the endo H-7 in **7** appeared with similar chemical shifts and identical multiplicities to the corresponding signals in the ^{1}H NMR spectrum of **5**. However, the existence in **5** of an acetoxyl group and the absence of the signal corresponding to the C-8 methyl in **7** clearly revealed that C-8 was the position at which the acetoxyl was located. Compound **5** is therefore 8-acetoxy-

Table 1. ^{1}H NMR spectral data of compounds **5**, **6** and **7** (60 MHz, TMS as internal standard, CCl$_4$)

	H-3	H-7 (endo)	Me-10	Me-9	H-8
5	5.20 *s*(*br*)	1.24 *d*, *J* = 8 Hz	1.68 *dd*	0.90 *s*	4.19 *s*
6	5.18 *s*(*br*)	1.19 *d*, *J* = 8 Hz	1.65 *dd*	0.89 *s*	3.66 *s*
7	5.12 *s*(*br*)	1.16 *d*, *J* = 8.5 Hz	1.65 *dd*	0.84 *s*	1.26 *s*

pin-2-ene (absolute configuration not determined) which has not been reported previously in the literature.

The more polar component of this essential oil, compound **6**, was an alcohol (IR 3340 cm^{-1}) whose ^{1}H NMR spectrum (Table 1) showed similar partial structures to those of **5**. Acetylation of **6** yielded **5**, confirming that it was pin-2-en-8-ol.

By silica gel CC and purification by preparative TLC and crystallization, three sesquiterpenes, **8**, **9** and **10** were isolated from the essential oil of the roots. The unsaturated hydrocarbon **8** (M$^+$ at *m/z* 204, $C_{15}H_{24}$), which in the ^{1}H NMR spectrum gave signals of CH=C, three Me–C and a Me–CH, together with two hydrogens of a cyclopropane ring, was identified as calarene [13] which was previously described in *A. debilis* [3].

The hydroxyderivative **9** (IR 3530 cm^{-1}) (M$^+$ at *m/z* 222, $C_{15}H_{26}O$) also gave signals of two cyclopropane hydrogens in the ^{1}H NMR spectrum together with a Me–C–OH and three Me–C, and was identified as maaliol [14]. This is the first report of maaliol or any other compound with the maaliane skeleton in the genus *Aristolochia*.

The IR (1675, 1630 cm^{-1}) and UV (243 nm) spectra of **10** corresponded to an α,β-unsaturated ketone (M$^+$ at *m/z* 218, $C_{15}H_{22}O$) which, as in the previous cases, gave signals of two cyclopropane hydrogens, three Me–C and one Me–CH in the ^{1}H NMR spectrum and it was identified as 1(10)-aristolen-2-one [15], previously described in *A. debilis* [4].

EXPERIMENTAL

General procedures. Mps uncorr. IR: film of KBr disc; ^{1}H NMR: 60 MHz, CCl_4 and $CDCl_3$, TMS as internal standard. EIMS: heated inlet system, 70 eV. UV: EtOH. TLC: silica gel (Merck No. 7731). Prep. TLC: 0.75 mm, silica gel (Merck No. 7748). CC: silica gel (Merck No. 7734). Rotations were determined in $CHCl_3$.

Plant material. Aristolochia longa was collected in La Bouza (Salamanca, Spain) in June, and identified by Professor B. Casaseca Mena. A herbarium specimen is deposited at the Department of Botany, Fac. Sciences, University of Salamanca, Spain.

Extraction and isolation: aerial parts. The air-dried aerial parts of *A. longa* (5.6 kg) were extracted with hexane in a Soxhlet and the extract (190.4 g) was steam-distilled to give after extraction the volatile fraction (1.66 g). Silica gel, silica gel–$AgNO_3$ (8 : 2) CC and prep. TLC yielded: **1** (148 mg), **4** (41 mg), **5** (60 mg), **2** (131 mg), **3** (17 mg) and **6** (105 mg).

β-Caryophyllene (**1**). Colourless oil. $[\alpha]_D - 18.5°$ ($CHCl_3$, *c* 4.75). IR ν_{max}^{film} cm^{-1}: 3080, 1675, 1635, 1277, 1183, 885. ^{1}H NMR (60 MHz, CCl_4): δ 5.21 (1H, *m*), 4.85 (1H, *s*), 4.73 (1H, *s*), (1.59) (3H, *s*), 0.99 (6H, *s*). EIMS 70 eV, *m/z* (rel. int.): 204 [M]$^+$ (25), 189 [M − Me]$^+$ (30), 175 (16), 161 (50), 133 (100), 91 (90).

Caryophyllene oxide (**2**). Colourless oil. $[\alpha]_D - 48.0°$ ($CHCl_3$, *c* 1.45). IR ν_{max}^{film} cm^{-1}: 3050, 1645, 1265, 970, 870. ^{1}H NMR (60 MHz, CCl_4): δ 4.88 (1H, *s*), 4.77 (1H, *s*), 1.11 (3H, *s*), 1.00 (6H, *s*). EIMS 70 eV, *m/z* (rel. int.): 220 [M]$^+$ (0.5), 205 [M − Me]$^+$ (0.8), 187 (1), 177 (3), 161 (4), 91 (71), 79 (100).

(S)-*Linalool* (**3**). Colourless oil. $[\alpha]_D + 17.3°$ ($CHCl_3$, *c* 0.35). IR ν_{max}^{film} cm^{-1}: 3400, 3080, 1645, 1120, 995, 925. ^{1}H NMR (60 MHz, CCl_4): δ 6.10–4.80 (4H, three of them in an ABX system), 1.62 (3H, *s*), 1.57 (3H, *s*), 1.20 (3H, *s*). EIMS 70 eV, *m/z* (rel. int.): 154 [M]$^+$ (0.1), 136 [M − H_2O]$^+$ (11), 121 [M − H_2O − Me]$^+$ (20), 107 (9), 93 (66), 71 (100).

Bornyl acetate (**4**). Colourless oil. IR ν_{max}^{film} cm^{-1}: 1725, 1240, 1025. ^{1}H NMR (60 MHz, CCl_4): δ 4.95–4.65 (1H, *m*), 2.00 (3H, *s*), 0.95 (3H, *s*), 0.89 (3H, *s*), 0.82 (3H, *s*).

8-*Acetoxy-pin-2-ene* (**5**). Colourless oil. $[\alpha]_D - 40.0°$ ($CHCl_3$, *c* 1.25). IR ν_{max}^{film} cm^{-1}: 1750, 1665, 1390, 1380, 1245, 1035. ^{1}H NMR: Table 1. EIMS 70 eV, *m/z* (rel. int.): 134 [M − AcOH]$^+$ (29), 119 (55), 107 (40), 105 (56), 91 (100), 79 (79).

Pin-2-en-8-ol (**6**). Colourless oil. $[\alpha]_D - 37.9°$ ($CHCl_3$, *c* 0.95). IR ν_{max}^{film} cm^{-1}: 3340, 3020, 1660, 1030, 785. ^{1}H NMR: Table 1. Ac_2O (1 ml) was added to 35 mg of **6** in 1 ml pyridine. The mixture was left at room temp. for 18 hr after which the usual procedure was followed, yielding 23 mg **5**.

Extraction and isolation: roots. The dried roots (3.5 kg) were extracted with hexane in a Soxhlet and the extract (10.1 g) was steam-distilled to give after extraction the volatile fraction (1.02 g). Silica gel CC and prep. TLC and crystallization yielded **8** (188 mg), **9** (410 mg) and **10** (15 mg).

Calarene (**8**). Colourless oil. $[\alpha]_D + 61.9°$ ($CHCl_3$, *c* 1.73). IR ν_{max}^{film} cm^{-1}: 1667, 1357, 1340, 1200, 1130, 1065, 1040, 987, 835, 773, 737. ^{1}H NMR (60 MHz, CCl_4): δ 5.18 (1H, *br s*), 0.95 (3H, *s*), 0.91 (3H, *s*), 0.88 (3H, *s*), 0.86 (3H, *d*, *J* = 6 Hz), 0.65–0.40 (2H, *m*). EIMS 70 eV, *m/z* (rel. int.): 204 [M]$^+$ (36), 189 [M − Me]$^+$ (27), 161 (99), 147 (28), 134 (32), 119 (65), 105 (98), 91 (100), 41 (96).

Maaliol (**9**). White needles, mp 103° (MeOH–H_2O). $[\alpha]_D + 32.6°$ ($CHCl_3$, *c* 1.87). IR ν_{max}^{KBr} cm^{-1}: 3530, 1480, 1467, 1455, 1395, 1180, 1110. ^{1}H NMR (60 MHz, CCl_4): δ 1.20 (3H, *s*), 1.05 (3H, *s*), 0.94 (3H, *s*), 0.87 (3H, *s*), 0.55 (2H, *m*). EIMS 70 eV, *m/z* (rel. int.): 222 [M]$^+$ (3), 204 [M − H_2O]$^+$ (76), 189 [M − H_2O − Me]$^+$ (100), 175 (15), 161 (65), 149 (37), 133 (33).

1(10)-*Aristolen-2-one* (**10**). White crystals, mp 41°. IR ν_{max}^{film} cm^{-1}: 1675, 1630, 1388, 1360, 1292, 875, 850. UV λ_{max}^{EtOH} nm (ε): 243 (7100). ^{1}H NMR (60 MHz, CCl_4): δ 5.58 (1H, *br s*), 1.22 (3H, *s*), 1.05 (3H, *d*, *J* = 6 Hz), 1.02 (3H, *s*), 0.99 (3H, *s*), 0.70–0.35 (2H, *m*). EIMS 70 eV, *m/z* (rel. int.): 218 [M]$^+$ (18), 203 [M − Me]$^+$ (24), 185 (34), 176 (57), 175 (45), 161 (58), 147 (60), 105 (72), 91 (100), 77 (84), 41 (65).

REFERENCES

1. Kupchan, S. M. and Doskotch, R. W. (1962) *J. Med. Pharm. Chem.* **5**, 657.
2. Munavalli, S. and Viel, C. (1969) *Ann. Pharm. Fr.* **27**, 449, 519, 601.
3. Krepinsky, J. and Giancarlo, J. (1970) *Collect. Czech. Chem. Commun.* **35**, 745.
4. Nishida, R. and Kumazawa, Z. (1973) *Agric. Biol. Chem.* **37**, 341.
5. Govindachari, T. and Mohamed, P. (1970) *Tetrahedron* **26**, 615.
6. Govindachari, T. and Parthasavathil, P. (1971) *Indian J. Chem.* **9**, 1310.
7. Pakrashi, S. C., Dastidar, P. P., Sarmistha, C. and Achari, B. (1980) *J. Org. Chem.* **45**, 4765.
8. Rucker, G., Langmann, B. and Siqueira, N. S. (1981) *Planta Med.* **41**, 143.
9. Stenlake, J. B. and Williams, W. D. (1954) *J. Pharm. Pharmacol.* **6**, 1005.
10. Dumont, P. (1958) *J. Pharm. Belg.* **13**, 3.
11. De Pascual-T, J., Bellido, I. S., San Feliciano, A. and Barrero, A. F. (1976) *An. Quim.* **72**, 657.
12. Bates, R. B. and Thalacker, V. P. (1968) *J. Org. Chem.* **33**, 1730.
13. Buechi, G., Greuter, F., Tokoroyama, T. (1962) *Tetrahedron Letters* 827.
14. Buchi, G., Schach, M., Wittenau, V. and White, D. M. (1959) *J. Am. Chem. Soc.* **81**, 1968.
15. Rucker, G. (1968) *Justus Liebigs Ann. Chem.* **717**, 221.