New 9*β*-Lanostane-Type Triterpenic and 13,14-*seco*-Steroidal Esters from the Roots of *Artemisia scoparia*

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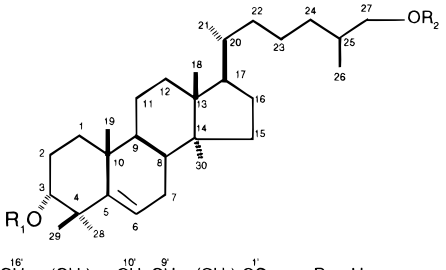
Phytochemical studies on the roots of *Artemisia scoparia*, collected from the Kullu Valley region of Himachal Pradesh, India, resulted in the isolation of one lanostane-type triterpenoid **1** and two 13,14-*seco*-steroids **4** and **8**. Their structures have been established as 9*β*-lanosta-5-ene-3α,27-diol 3α-palmitoleate, 13,14-*seco*-cholest-7-ene-3,6α,27-triol 3,27-diocta-8′,6′-dienoate, and 13,14-*seco*-cholest-5-ene-3*β*,27-diol 27-methanoate 3*β*-hexadeca-11′,13′,15′-trien-1′-oate on the basis of the spectroscopic techniques and chemical means.

Artemisia scoparia Waldst. & Kit. (Compositae), a faintly scented, very slender, branched annual herb, is found in the Western Himalayas at altitudes of 1500−2100 m, in Punjab and the upper Gangetic plains. The plant is used as a purgative and for earache and its smoke used for burns.[1−3] Inflorescence of *A. scoporia* is reported to contain coumarins scoparone[1,4] and scopoletin,[1] flavonoids 7-methylaromadendrin, rhamnocitrin, eupatolitin, cirsimaritin, 7-methylesculatin, rutin, quercetin 3-glucogalactoside, kaempferol 3-glucogalactoside, quercetin 3,7-rutinosogalactoside, artemetin and casticin,[1,5] and capillarin.[5,6] The present paper describes the isolation and characterization of three new chemical constituents from roots of the plant.

Compound **1**, named lanoscopariol, had the composition of $C_{46}H_{80}O_3$ established on the basis of positive ion FABMS and ^{13}C-NMR data. It responded positively to the Liebermann−Burchard test, indicative of a triterpenoid skeleton. Its IR spectrum exhibited hydroxyl (3445, 1057, and 1024 cm^{-1}) and ester linkage (1731 cm^{-1}) absorption bands. Its ^{1}H-NMR spectrum is consistent with the proposed structure and clearly showed olefinic protons at δ 5.366 (m, H-6) and 5.146 (m, H-9′, 10′), hydroxymethylene protons as two doublets at δ 4.142 and 4.098 (J = 6.50 Hz each), an α-carbinol proton as a broad multiplet at δ 3.666 (dd, J = 4.5, 5.5 Hz, H-3), and seven methyl functionalities all attached to saturated carbons in the range of δ 1.020−0.679. Its broad-band-decoupled ^{13}C-NMR spectrum and ^{13}C-attached proton test (APT) spectrum exhibited the presence of 46 carbon signals (CH_3 × 8, CH_2 × 22, −CH × 9, −C− × 4, CH_2O × 1, CHOH × 1, CO × 1). The significant fragment ions at m/z 443, 426, 314, 297, 253, and 235 reflected the presence of C_{16}-unsaturated fatty acid ester linked at C-3 and a $C_{10}H_{21}O$ saturated side chain containing a hydroxyl methylene function. The structure **1** was fully supported by extensive 2D-NMR experiments. A ^{1}H−^{13}C heteronuclear chemical shift correlation spectrum (HETEROCOSY) was recorded to locate the chemical shifts of various protons. The signals of C-3, C-17, C-18, C-19, C-21, C-23, and C-26 in ^{13}C-NMR spectrum could easily be correlated with the chemical shifts of their respective protons in the ^{1}H-NMR spectrum. Acetylation of compound **1** with Ac_2O gave the monoacetyl derivative **2**.



1: R_1 = $CH_3^{16'}-(CH_2)_5-CH^{10'}=CH^{9'}-(CH_2)_7CO^{1'}$; R_2 = H

2: R_1 = $CH_3(CH_2)_5CH=CH-(CH_2)_7CO$; R_2 = Ac

3: R_1 = R_2 = H

Hydrolysis of **1** with 5% KOH in EtOH at 45 °C for 1 h yielded a mixture containing a lanostene-type triterpene and a fatty acid. The triterpene **3** had a molecular ion peak at m/z 446 corresponding to $C_{30}H_{54}O_2$. Its ^{1}H-NMR spectrum displayed a one-proton multiplet at δ 5.36 assigned to H-6, a one-proton double doublet at δ 3.30 (J = 4.5, 5.5 Hz) ascribed to H-3β, and two one proton each doublets at 4.16 (J = 6.5 Hz) and 3.96 (J = 6.5 Hz) associated with C-27 hydroxymethylene groups. The methyl signals appeared at δ 0.73 (s, Me-18), 0.83 (d, J = 6.0 Hz, Me-26), 0.96 (s, Me-28), 0.86 (s, Me-29), and 0.80 (s, Me-30). The compound **3** was characterized as lanost-5-ene-3α,27-diol. The acid was identified as palmitoleic acid by comparing melting point and co-TLC. On the basis of this evidence, the structure of lanoscopariol **1** was elucidated to be 9*β*-lanosta-5-ene-3α,27-diol 3α-palmitoleate.

Compound **4**, designated artemisterol A, positive in the Liebermann−Burchard test, was obtained as cream-colored needles. Its IR spectrum showed hydroxyl (3420 cm^{-1}), carbonyl (1722 cm^{-1}), olefinic (1630, 1606 cm^{-1}), and unsaturated methylene (907 cm^{-1}) absorption bands. The compound was assigned the molecular formula $C_{43}H_{68}O_5$ by positive ion FABMS. The ^{13}C-NMR spectrum [proton-noise-decoupled (PND) and APT (7) experiments] showed 43 carbon atoms of the molecule to consist of one carbonyl, two quaternary (one sp^3 and one

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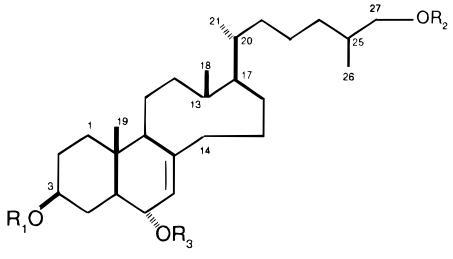
sp^2), 15 methine (7 sp^2 and 8 sp^3), 20 methylene (two sp^2, 18 sp^3), and four methyl groups (in total $C_{43}H_{67}$). The ^{1}H-NMR data indicated one oxygen-substituted methylene δ 4.179, 3.928 (each br s), two oxygen-substituted methines δ 3.530 (($w_{1/2}$ = 21.76), 3.076 (m)), five unsaturated methines (δ 5.800 m (2H), 5.540 m, 5.445m, 5.350 d (J = 8.16 Hz)), and two vinyl groups ((δ H 6.167 m, 6.300 m), 5.142 d (J = 7.40 Hz), 5.065 d (J = 7.40 Hz), 5.104 (d = 7.40), 4.942 d (J = 7.02 Hz)). Appearance of Me-18 at δ 0.689 as a doublet (J = 6.60 Hz) indicated a C/D *seco* ring. The ^{13}C-NMR shifts for the protonated carbon resonances were correlated by the ^{1}H−^{13}C COSY spectrum. The one OH group (completing the 68 protons of the molecule) was confirmed by a microacetylation of **4** (5 mg) to monoacetate **5** ν max 1730, 1720 cm^{-1}). The most significant evidence for the structure elucidation of **4** was its FAB mass spectrum; apart from the molecular ion, the significant ion fragments at m/z 413 [M - side chain, $C_{16}H_{27}O_2$, 251]$^+$, 395 [413 - H_2O]$^+$, 370 [413 - C_3H_7]$^+$, 352 [370 - H_2O]$^+$, and 239 [255 − Me]$^+$ suggested the molecule possessed a saturated $C_7H_{11}CO$ side chain, hydroxyl function, and another $C_7H_{11}CO$ ester function at C-3. The ion fragments at m/z 273 [413 - $C_8H_{12}O_2$]$^+$, 264 [$C_{6,7}$ - $C_{9,10}$ fission]$^+$, 179 [$C_{2,3}$ - $C_{5,10}$ - $C_{5,6}$ fission]$^+$, and 209 [$C_{2,3}$ - $C_{5,10}$ - $C_{6,7}$ fission]$^+$ and the ^{13}C-NMR signal near δ 62.51 (8) indicated the presence of an α-hydroxyl group at C-6. Hydrolysis of **4** with alcoholic KOH formed a steroidal aglycon **6** and an acid **7**. The sterol **6** showed characteristic IR absorption bands for the hydroxyl group (3400, 3350 cm^{-1}) and unsaturation (1610 cm^{-1}). Its ^{1}H-NMR spectrum displayed doublets at δ 5.30 (1H, J = 6.6 Hz, H-7), 0.70 (3H, J = 6.6 Hz, Me-18), 0.93 (3H, J = 6.3 Hz, Me-21), 0.83 (3H, J = 6.6 Hz, Me-26), 4.03 (1H, J = 6.0 Hz, CH_2-27a), and 3.90 (1H, J = 6.0 Hz, CH_2-27b), two one-proton multiplets at δ 3.30 ($w_{1/2}$ = 21.7 Hz, H-3 α) and 3.03 (H-6β), and a three-proton singlet at δ 1.06 (Me-19). Its MS had a molecular ion peak at m/z 420 ($C_{27}H_{48}O_3$). On the basis of this evidence, the steroidal aglycon **6** was identified as 13,-14-*seco*-cholest-7-ene-3β,7α,27-triol. The acid **7**, characterized as octa-8,6-dienoic acid, showed IR characteristic bands for a carboxylic group (3300, 1690 cm^{-1}) and unsaturation (1600 cm^{-1}). Its MS had molecular ion peak at m/z 140 ($C_8H_{12}O_2$). The ^{1}H-NMR spectrum of **7** displayed one-proton olefinic protons at δ 6.170 (m, H-7), 5.810 (m, H-6), 5.500 (m, H-5), 5.052 (d, J = 12.5 Hz, H-8a), and 4.972 (d, J = 11.0 Hz, H-8b). These data establish artemisterol A (**4**) as 13,14-*seco*-cholest-7-ene-3,6α,27-triol 3,27-diocta-8′,6′-dienoate.



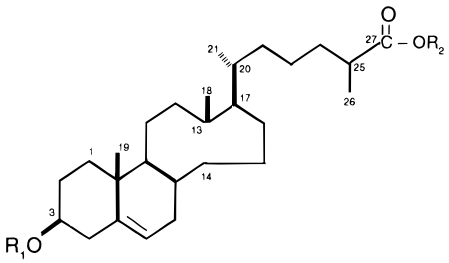
4: R_1 = R_2 = $CH_2^{8'}=CH^{7'}-CH^{6'}=CH^{5'}-CH(CH_2)_3CO^{1'}$; R_3 = H

5: R_1 = R_2 = $CH_2=CH-CH=CH-(CH_2)_3CO$; R_3 = Ac

6: R_1 = R_2 = R_3 = H

7: $CH_2=CH-CH=CH-(CH_2)_3-COOH$

Compound **8**, designated artemisterol B, positive in the Liebermann−Burchard test, had a molecular formula of $C_{44}H_{72}O_4$ on the basis of positive FABMS ([M]$^+$ 664) and the ^{13}C-NMR spectrum. The ^{1}H-NMR spectrum of **8** displayed signals for six trisubstituted olefinic protons at δ 7.578 m (H-13, H-14), 6.300 m (H-12,H-15), 6.167 m (H-11), and 5.344 m (H-6), one vinylic methylene group at δ 5.178 m (H-16′a) and 5.025 m (H-16′b), three secondary methyl functions at δ 0.697 (d, J = 6.6 Hz, H_3-18), 0.936 (d, J = 6.3 Hz, H_3-21), and 0.860 (d, J = 6.6 Hz, H_3-26), one tertiary methyl group at δ 1.007 (s, H_3-19), and a methoxy group at δ 3.929. The ^{13}C-NMR spectrum of **8** exhibited signals due to four methyl, 21 methylene, one vinylic methylene, 13 methine (7 sp^3, 6 sp^2), two ester carbonyl, and one methoxy groups. Multiplicity of each carbon was determined by APT experiments, and ^{13}C-NMR values of important carbons were corelated with ^{1}H-NMR values in ^{1}H−^{13}C corelated 2D spectrum. In addition, the presence of ring CD *seco* was inferred from a doublet at δ 0.697 (J = 6.60 Hz) in the ^{1}H-NMR spectrum assigned to H_3-18.



8: R_1 = $CH_2^{16'}=CH^{15'}-CH^{14'}=CH^{13'}-CH^{12'}=CH^{11'}-(CH_2)_9CO^{1'}$; R_2 = CH_3

9: R_1 = R_2 = H

10: $CH_2=CH-CH=CH-CH=CH-(CH_2)_9-COOH$

Hydrolysis of **8** with alcoholic KOH furnished steroidal aglycon **9** and an acid **10**. The steroidal component **9** had molecular ion peak at m/z 418 ($C_{27}H_{46}O_3$) and exhibited typical IR absorptions at 3350 (OH), 1700 (COOH), and 1605 cm^{-1} (C=C). Its ^{1}H-NMR spectrum showed two one-proton multiplets at δ 5.33 (H-6) and 3.36 ($w_{1/2}$ = 21.5 Hz, H-3α), a three-proton singlet at δ 1.00 (Me-19), and three three-proton doublets at δ 0.70 (J = 6.6 Hz, Me-18), 0.96 (J = 6.3 Hz, Me-21), and 0.83 (J = 6.6 Hz, Me-26). The steroid **9** has been identified as 13,14-*seco*-3β-hydroxycholes-5-en-17-oic acid. The acid **10** showed IR absorption bands for carboxylic group (3350, 1690 cm^{-1}). The ^{1}H-NMR of **10** exhibited three multiplets at δ 7.504 (1H, H-14), 6.51 (1H, H-13), and 6.19 (3H, H-11, H-12, H-15) and two one-proton doublets at δ 5.29 (J = 5.26 Hz, H-16a) and 5.04 (J = 6.0 Hz, H - 16b). Its EIMS displayed a molecular ion peak at m/z 250 ($C_{16}H_{26}O_2$). The acid **10** was characterized as *n*-hexadeca-11,13,15-trien-1-oic acid. This was confirmed by the signal in the FABMS spectrum of **8** at m/z 414 [M - C_{15} - H_{25} - COOH]$^+$ due to expulsion of the acid $C_{15}H_{25}COOH$ at m/z 250 (base peak). Other characteristic peaks were formed at m/z 430 [M - $C_{15}H_{25}CO$]$^+$, 414 [M - $C_{15}H_{25}COOH$]$^+$, 257 [414 - side chain, $C_9H_{17}O_2$]$^+$, and 242 [257 - Me]$^+$. The ion fragments at m/z 315 [$C_{2,3}$ - $C_{5,10}$ - $C_{7,8}$ fission]$^+$, 308 [$C_{6,7}$ - $C_{9,10}$ fission]$^+$, 301 [$C_{2,3}$ - $C_{5,10}$ - $C_{7,8}$ fission]$^+$, 294 [$C_{7,8}$ - $C_{9,10}$ fission]$^+$, 268, and 396 [$C_{8,14}$ - $C_{9,11}$ fission]$^+$ confirmed the ester linkage at C-3 and unsaturation at C-5. These data indicated that the structure of arte-

misterol B (**8**) must be 13,14-*seco*-cholest-5-ene-3β,27-diol 27-methanoate 3β-hexadeca-11′,13′,15′-trien-1′-oate.

Experimental Section

General Experimental Procedures. Melting points (mp) were determined in capillaries on a Perfit melting point apparatus and are uncorrected. IR spectra were measured by a Perkin-Elmer 1600 IR spectrophotometer in KBr pellets. UV spectra (λ max) were obtained on a Hewlett-Packard 8450 spectrophotometer in MeOH. ^{1}H-NMR and ^{13}C-NMR and COSY spectra data were recorded on Brucker 400 MHz and 100.53 MHz instruments, respectively, in $CDCl_3$. TMS was used as internal reference for NMR measurements. Chemical shifts are expressed in δ (ppm), and coupling constants are in Hz. The APT experiments were carried out with ϕ = 45°, 90°, and 135°. The high-resolution mass spectra were screened on a Clevland mass spectrometer. CC was carried out using silica gel (60-120 mesh). TLC was performed on Si gel G; solvent systems were petroleum ether−toluene−ethyl acetate (10:5:3), benzene−$CHCl_3$ (1:1), and $CHCl_3$−MeOH (1:1). Iodine vapors, perchloric acid, ceric ammonium sulfate, and UV light were used for visualization of TLC spots.

Preparation of Plant Material. The roots of *A. scoparia* were collected from the Kullu valley region in the State of Himachal Pradesh, India, and air dried. The plant was identified by Dr. M. P. Sharma, taxonomist in the Department of Botony, Jamia Hamdard, Hamdard University, New Delhi, where a voucher specimen is preserved.

Extraction, Separation and Purification of Compounds. The pulverized sample (2905 g) was extracted exhaustively in a Soxhlet apparatus with EtOH (95%). The extract was concentrated in *vacuo* to yield a thick, viscous, dark reddish brown mass (105 g). This material was adsorbed on silica gel (100 g) with constant stirring until completely dried and subjected to a silica gel column prepared in petroleum ether (bp 60−80 °C). The column was eluted successively with petroleum ether, petroleum ether−$CHCl_3$ (9:1, 7:3, 1:1, 3:7, 1:4), $CHCl_3$, $CHCl_3$−MeOH (9.5:0.5, 9:1, 4:1, 3:1, 1:1, 1:3), and MeOH. Compound **1** (0.3 g) was eluted in petroleum ether−$CHCl_3$ (3:1). Compound **5** (1.5 g) and compound **8** (0.25 g) were obtained from $CHCl_3$ fractions and crystallized from the $CHCl_3$−MeOH (1:1) mixture.

Lanoscopariol (1). Compound **1** was obtained as a colorless semisolid: UV (CH_3OH) λ max nm (log ϵ) 244 (4.2); IR (KBr) ν max cm^{-1} 3445, 2925, 2850, 1731, 1460, 1374, 1255, 1180, 1089, 1057, 1024, 908 and 730 cm^{-1}; ^{1}H-NMR δ 3.666 (1H, dd, J = 4.50, 5.50 Hz, H-3β), 5.366 (1H, m, H-6), 0.767 (3 H, s, H_3-18), 1.020 (3H, s, H_3-19), 0.937 (3H, d, J = 6.30 Hz, H_3-21), 0.832 (3H, d, J = 6.60 Hz, H_3-26), 4.142 (1H, d, J = 6.50 Hz, H_2-27a), 4.098 (1H, d, J = 6.50 Hz, H_2-27b), 0.981 (3H, s, H_3-28), 0.880 (3H, s, H_3-29), 0.847 (3H, s, H_3-30), 5.146 (2H, m, H-9′, H-10′), 0.679 (3H, t, J = 6.50 Hz, H_3-16′); ^{13}C-NMR δ 38.17 (C-1), 33.94 (C-2), 73.76 (C-3), 42.32 (C-4), 139.70 (C-5), 122.61 (C-6), 31.94 (C-7), 32.48 (C-8), 50.04 (C-9), 36.60 (C-10), 22.70 (C-11), 37.01 (C-12), 45.84 (C-13), 51.25 (C-14), 24.30 (C-15), 31.94 (C-16), 56.70 (C-17), 14.26 (C-18), 18.79 (C-19), 36.16 (C-20), 18.27 (C-21), 37.80 (C-22), 26.32 (C-23), 39.74 (C-24), 31.87 (C-25), 19.04 (C-26), 64.43 (C-27), 11.99 (C-28), 20.22 (C-29), 19.83 (C-30), 173.29 (C-1′), 60.17 (C-2′), 29.71 (C-3′), 29.48 (C-4′), 29.37 (C-5′), 29.28 (C-6′), 34.65 (C-7′), 37.01 (C-8′), 138.33 (C-9′), 129.99 (C-10′), 42.32 (C-11′), 29.10 (C-12′), 28.66 (C-13′), 27.22 (C-14′), 25.00 (C-15′), 11.86 (C-16′); positive ion FABMS m/z (rel int) [M]$^+$ 680 ($C_{46}H_{80}O_3$) (1.0), 443 [M - $C_{15}H_{29}CO$]$^+$ (1.1), 428 [443 - Me]$^+$ (2.7), 426 [M - $C_{15}H_{29}COO$]$^+$ (2.4), 411 [426 - Me]$^+$ (26.9), 409 (10.9), 397 (11.7), 395 (12.5), 314 [443 - SC, $C_8H_{17}O$, 129]$^+$ (3.3), 297(2.4), 285 (14.8), 253 [$C_{15}H_{29}COO$]$^+$ (5.3), 235 [$C_{15}H_{29}CO$]$^+$ (2.9), 229 (4.1), 129 (29.9), 123 (23.6), 109 (46.3), 95 (100).

Acetylation of 1. Compound **1** (10 mg) was treated with a mixture of Ac_2O (0.5 mL) and pyridine (0.5 mL) at room temperature. Excess of MeOH was added to the mixture and the solvent removed in *vacuo*. The residue was purified by preparative TLC (solvent C_6H_6−$CHCl_3$ 1:1) to give monoacetate **2** as an amorphous powder: IR ν max (KBr) 1730, 1725 cm^{-1}.

Hydrolysis of 1. A solution of **1** (10 mg) in ethanolic KOH (5%, 5 mL) was heated at 45 °C for 1 h. The mixture was evaporated to dryness, dissolved in water, and extracted with ether (2 × 10 mL). The ether layer was washed with water, dried over Na_2SO_4, and evaporated to obtain the triterpene **3**: mp 161−162 °C; IR ν (KBr) cm^{-1} 3440, 2935, 2845, 1465, 1250, 1085, 1030 cm^{-1}; ^{1}H-NMR δ 5.36 (1H, m, H-6), 3.30 (1H, dd, J = 4.5, 5.5 Hz, H-3β), 0.73 (3H, s, H_3-18), 0.73 (3H, s, H_3-18), 1.00 (3H, s, H_3-19), 0.90 (3H, d, J = 6.0 Hz, H_3-21), 0.83 (3H, d, J = 6.0 Hz, H_3-26), 4.16 (1H, d, J = 6.5 Hz, H_2-27a), 3.96 (1H, d, J = 6.5 Hz, H_2-27b), 0.96 (3H, s, H_3-28), 0.86 (3H, s, H_3-29), 0.80 (3H, s, H_3-30), EIMS m/z (rel int) 446 [M]$^+$ ($C_{30}H_{54}O_2$) (2.1), 431 [M - Me]$^+$ (1.3), 428 [M - H_2O]$^+$ (1.1), 317 [M - SC]$^+$ (5.4), 302 [M - SC - Me]$^+$ (3.3), 299 [M - SC - H_2O] (2.8), 256 [299 - ring D]$^+$ (4.2). The aqueous layer was acidified, reextracted with ether, washed with water, and dried to get palmitoleic acid, mp 40−41 °C, co-TLC (*n*-BuOH:EtOH: H_2O, 4:1:2.2).

Artemisterol A (4). Compound **4** was obtained as cream-colored needles from $CHCl_3$−CH_3OH (1:1): mp 128−130 °C; UV (CH_3OH) λ max nm (log ϵ) 246, 287 nm, (2.3, 1.7); IR (KBr) ν max cm^{-1} 3420, 2955, 2860, 1722, 1630, 1606, 1503, 1458, 1414, 1378, 1319, 1275, 1248, 1055, 907, 797, 730; ^{1}H-NMR δ 3.530 (1H, br m, $w_{1/2}$ = 21.76 Hz, H-3α), 3.076 (1H, m, H-6β), 5.350 (1H, d, J = 8.16 Hz, H-7), 0.689 (3H, d, J = 6.60 Hz, H_3-18), 1.036 (3H, s, H_3-19), 0.938 (3H, d, J = 6.30 Hz, H_3-21), 0.860 (3H, d, J = 6.60 Hz, H_3-26), 4.179 (1H, br s, H_2-27a), 3.928 (1H, br s, H_2-27b), 5.540 (1H, m, H-5′), 5.800 (1H, m, H-6′), 6.300 (1H, m, H-7′), 5.142 (1H, d, J = 7.02 Hz, H-8′a), 5.065 (1H, d, J = 8.30 Hz, H-8′b), 5.445 (1H, m, H-5″), 5.800 (1H, m, H-6″), 6.167 (1H, m, H-7″), 5.104 (1H, d, J = 7.40 Hz, H-8″a), 4.942 d (1H, d, J = 7.40 Hz, H-8″b); ^{13}C-NMR δ 38.76 (C-1), 30.91 (C-2), 70.81 (C-3), 41.31 (C-4), 44.82 (C-5), 62.51 (C-6), 32.70 (C-7), 32.93 (C-8), 50.22 (C-9), 36.24 (C-10), 21.67 (C-11), 41.26 (C-12), 39.48 (C-13), 41.31 (C-14), 24.39 (C-15), 28.05 (C-16), 55.04 (C-17), 11.23 (C-18), 20.05 (C-19), 35.49 (C-20), 18.81 (C-21), 38.67 (C-22), 26.19 (C-23), 25.06 (C-24), 30.62 (C-25), 20.20 (C-26), 63.56 (C-27), 177.90 (C-1′), 41.20 (C-2′), 23.35 (C-3′), 28.68 (C-4′), 129.21 (C-5′), 138.02 (C-6′), 135.15 (C-7′), 116.01 (C-8′), 177.90 (C-1″), 41.20 (C-2″), 23.29 (C-3″), 28.34 (C-4″), 128.26 (C-5″), 137.37 (C-6″), 131.97 (C-7″), 113.27 (C-8″); positive ion FABMS m/z (rel int) [M]$^+$ 664 ($C_{43}H_{68}O_5$) (2.5), 646 [M - H_2O]$^+$ (1.1), 427 (2.2), 413 [M

- SC, $C_{16}H_{27}O_2$, 251]$^+$ (24.0), 411 (20.4), 398 (6.8), 395 (6.2), 379 (2.0), 370 [413 - C_3H_7]$^+$ (1.5), 352 [370 - H_2O]$^+$ (1.2), 302 [$C_{8,1}-C_{9,11}$ fission]$^+$ (1.6), 290 [413-$C_7H_{11}CO$, 123]$^+$ (1.4), 276 [$C_{7,8}$-$C_{9,10}$ fission]$^+$ (2.0), 273 [413 - CH_2=CHCH=CH$(CH_2)_3$COOH]$^+$ (2.4), 264 [$C_{6,7}-C_{9,10}$ fission]$^+$ (2.6), 255 [273 - H_2O]$^+$ (5.4), 251 (11.9), 240 [255 - CH_3]$^+$ (4.6), 223 [$C_{2,3}-C_{4,10}-C_{7,8}$ fission]$^+$ (3.9), 225 [240 - CH_3]$^+$ (3.6), 209 [$C_{2,3}-C_{510}-C_{6,7}$fission]$^+$, 194 [$C_{1,10}-C_{4,5}$ fission]$^+$ (4.5), (6.2), 179 (10.5), 171 (10.6), 165 (13.7), 159 (24.3), 157 (17.2), 135 (30.5), 133 (36.2), 131 (29.7), 129 (26.0), 95 (100).

Acetylation of 4. Artemisterol A (**4**) (5 mg) was heated with Ac_2O−pyridine (1:1) for 1 h and left overnight at room temperature. Evaporation under reduced pressure of the reaction mixture afforded compound **5**: semisolid; IR ν max (KBr) 1730, 1720 cm^{-1}.

Hydrolysis of 4. Compound **4** (10 mg) was heated with ethanolic KOH (5%, 3 mL) for 1 h. The reaction mixture was extracted with $CHCl_3$, the organic layer was washed twice with H_2O (3 × 5 mL) and dried (Na_2SO_4) and the solvent evaporated to yield a steroidal aglycon **6**: mp 135−136 °C; IR (KBr) ν max cm^{-1} 3400, 3350, 2965, 2845, 1610, 1460, 1370, 1320, 1270, 1050, 920, 810, 715; ^{1}H-NMR δ 5.30 (1H, d, J = 6.6 Hz, H-7), 3.30 (1H, br m, $w_{1/2}$ = 21.70 Hz, H-3α), 3.03 (1H, m, H-6β), 0.70 (3H, d, J = 6.6 Hz, H_3-18), 1.06 (3H, s, H_3-19), 0.93 (3H, d, J = 6.3 Hz, H_3-21), 0.83 (3H, d, J = 6.6 Hz, H_3-26), 4.03 (1H, d, J = 6.0 Hz, H_2-27a), 3.90 (1H, d, J = 6.0 Hz, H_2-27b); EIMS m/z (rel int) 420 [M]$^+$ ($C_{27}H_{48}O_3$) (5.3), 405 [M - Me]$^+$ (1.2), 402 [M - H_2O]$^+$ (21.6), 384 [402 - H_2O]$^+$ (5.1), 273 [M - H_2O - SC]$^+$ (4.2), 258 [273 - Me]$^+$ (3.3), 255 [273 - H_2O]$^+$ (4.4), 212 (3.8), 72 (61.3), 55 (100). The aqueous residue of the reaction mixture was acidified (pH 5.0) and extracted with $CHCl_3$ (3 × 5 mL) and the $CHCl_3$ layer washed with water, dried over Na_2SO_4, and evaporated to get the acid **7**: IR ν max 3300, 1690, 1600 cm^{-1}; ^{1}H-NMR δ 6.170 m (H-7), 5.810 m (H-6), 5.500 m (H-5), 5.052 d (J = 12.5 Hz, H-8a), 4.972 d (J = 11.0 Hz, H-8b); EIMS m/z (rel int) 140 [M]$^+$ ($C_8H_{12}O_2$) (4.5), 96 [M - CO_2]$^+$ (21.3), 82 (53.2), 68 (56.4), 54 (85.2).

Artemisterol B (8). Compound **8** was obtained as a white amorphous powder from $CHCl_3$−CH_3OH (1:1): mp 118−120 °C; UV (CH_3OH) λ max nm (log ϵ) 243, 323 (1.2, 2.8); IR (KBr) ν max cm^{-1} 3020, 2950, 2855, 1726, 1595, 1455, 1435, 1395, 1350, 1270, 1212, 1170, 1115, 756; ^{1}H-NMR δ 3.589 (1H, br m, $w_{1/2}$ = 23.04 Hz, H-3α), 5.344 (1H, br m, H-6), 0.697 (3H, d, J = 6.60 Hz, H_3-18), 1.007 (1H, br s, H_3-19), 0.936 (3H, d, J = 6.30 Hz, H_3-21), 0.860 (3H, d, J = 6.60 Hz, H_3-26), 3.939 (3H, s, OCH_3), 6.167 (1H, m, H-11′), 6.300 (1H, m, H-12′), 7.578 (2H, m, H-13′, H-14′), 6.300 (1H, m, H-15′), 5.178 (1H, m, H-16′a), 5.025 (1H, m, H-16′b); ^{13}C-NMR δ 37.24 (C-1), 33.86 (C-2), 71.84 (C-3), 45.82 (C-4), 140.72 (C-5), 121.73 (C-6), 31.88 (C-7), 31.93 (C-8), 50.14 (C-9), 36.50 (C-10), 21.07 (C-11), 39.76 (C-12), 31.61 (C-13), 40.50 (C-14), 24.30 (C-15), 28.24 (C-16), 56.05 (C-17), 11.86 (C-18), 19.82 (C-19), 36.14 (C-20), 18.78 (C-21), 39.76 (C-22), 26.06 (C-23), 25.41 (C-24), 29.70 (C-25), 19.39 (C-26), 178.60 (C-27), 58.00 (OCH_3), 178.60 (C-1′), 29.45 (C-2′), 29.71 (C-3′), 29.08 (C-4′), 28.92 (C-5′), 28.76 (C-6′), 23.06 (C-7′), 23.06 (C-8′), 24.36 (C-9′), 29.36 (C-10′), 105.12 (C-11′), 114.31 (C-12′), 129.27 (C-13′), 143.64 (C-14′), 138.32 (C-15′), 103.58 (C-16′); positive ion FABMS m/z (rel int) [M]$^+$ 664 ($C_{44}H_{72}O_4$) (0.5), 430 (1.5), 427 (1.6), 414 [M - $C_{15}H_{25}$ - COOH]$^+$ (4.3), 411 (4.3), 399[414 - CH_3]$^+$ (2.1), 396 (1.3), 383 (1.7), 315 (1.3), 308 (2.3), 301 (1.3), 294 (1.6), 285 [414 - SC, $C_8H_{17}O$, 129]$^+$ (1.9), 270 [285 - CH_3]$^+$ (2.4), 268 (2.6), 257 (3.3), 253 (10.6), 250 [$C_{15}H_{25}$COOH]$^+$ (100), 242 (2.6), 237 (12.6), 235 (10.3), 221 (27.6), 165 (12.6), 151 (19.4), 148 (13.4), 145 (10.3), 135 (35.9), 132 (16.3), 129 (10.2), 123 (12.5), 121 (24.9), 119 (70.0), 115 (11.5), 109 (19.5), 106 (20.1), 102 (58.5), 95 (36.6).

Alkaline Hydrolysis of 8. Compound **8** (20 mg) was dissolved in 5 mL of 2 N alcoholic NaOH, heated in a water bath for 30 min, and allowed to stand overnight. This solution was extracted with Et_2O to remove the aglycon sterol **9**: mp 161−162 °C; IR ν max (KBr) cm^{-1} 3350, 2955, 2845, 1700, 1605, 1460, 1435, 1385, 1345, 1210, 1120, 755 cm^{-1}; ^{1}H-NMR δ 5.33 (1H, br m, H-6), 3.36 (1H, br m, $w_{1/2}$ = 21.5 Hz, H-3α), 0.70 (3H, d, J = 6.6 Hz, H_3-18), 1.00 (1H, br s, H_3-19), 0.96 (3H, d, J = 6.3 Hz, H_3-21), 0.83 (3H, d, J = 6.6 Hz, H_3-26); EIMS m/z (rel int) 418 [M]$^+$ ($C_{27}H_{46}O_3$) (6.2), 403 [M - Me]$^+$ (3.7), 400 [M - H_2O]$^+$ (8.3), 385 (3.5), 374 [M - CO_2]$^+$ (2.1), 275 [418 - SC]$^+$ (5.5), 260 [275 - Me]$^+$ (3.7), 257 [257 - H_2O]$^+$ (6.3), 213 (5.7), 72 (51.6), 55 (100).

Acidification with dilute HCl was followed by extraction with Et_2O. The Et_2O extracts were evaporated in *vacuo*. Purification of the extract by preparative TLC gave the acid **10**: IR ν max 3350, 1690 cm^{-1}; ^{1}H-NMR δ 7.50 m (H-14), 6.51 m (H-13), 6.19 m (H-11, H-12, H-15), 5.29 d (J = 5.26 Hz, H-16a), 5.04 d (J = 6.0 Hz, H-16b); EIMS 250 [M]$^+$ ($C_{16}H_{26}O_2$) (11.2), 206 [M - CO_2]$^+$ (9.6), 192 (21.2), 178 (25.6), 164 (27.1), 150 (29.2), 136 (31.2), 122 (33.0), 108 (35.6), 94 (37.8), 79 (53.1), 55 (100).

References and Notes

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