Studies on Nepalese Crude Drugs. XXIV.[1] Diterpenoid Constituents of the Leaves of *Scutellaria repens* BUCH.-HAM. ex D. DON

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From the leaves of *Scutellaria repens*, sixteen new neoclerodane-type diterpenes named scuterepenins A_1, A_2, B, C_1, C_2, D_1, D_2, E, F_1, F_2, G_1 and G_2, and scuterepenosides A_1, A_2, A_3 and A_4, have been isolated along with a new 9,11-secoabietane-type diterpene named scuterepenin H. The structures of these compounds have been determined by spectroscopic and chemical methods as follows: scuterepenin A_1, (4*R*,11*S*,13*R*)-7β-*trans*-cinnamoyloxy-4,6α,13,18-tetrahydroxy-11,16 : 15,16-diepoxy-1-neoclerodanone; scuterepenin A_2, *cis*-cinnamoyl form of A_1; scuterepenin B, (4*R*,11*S*,13*R*)-7β-*trans*-cinnamoyloxy-2α,4,6α,13,18-pentahydroxy-11,16 : 15,16-diepoxy-1-neoclerodanone; scuterepenin C_1, (4*R*,11*S*,13*R*)-6α-*trans*-cinnamoyloxy-7β,13-dihydroxy-4,18 : 11,16 : 15,16-triepoxy-1-neoclerodanone; scuterepenin C_2, *cis*-cinnamoyl form of C_1; scuterepenin D_1, (4*R*,11*S,13*R**)-6α-*trans*-cinnamoyloxy-1β,7β-diacetoxy-11,16 : 15,16-diepoxy-18-neoclerodanal; scuterepenin D_2, *cis*-cinnamoyl form of D_1; scuterepenin E, (4*R*,11*S**,13*R**)-1β-acetoxy-7β-*trans*-cinnamoyloxy-6α-hydroxy-11,16 : 15,16-diepoxy-18-neoclerodanal; scuterepenin F_1, (4*R*,11*S**,13*R**)-1β-*O*-acetyl-7β-*O*-*trans*-cinnamoyl-18β-*O*-methyl-6α,18 : 11,16 : 15,16-triepoxyneoclerodane-1,7,18-triol; scuterepenin F_2, *cis*-cinnamoyl form of F_1; scuterepenin G_1, (4*R*,7*R*,11*S*,13*R*)-6α-*O*-*trans*-cinnamoyl-1,16 : 4,18 : 11,16-triepoxyneoclerodane-6,7,15-triol; scuterepenin G_2, *cis*-cinnamoyl form of G_1; scuterepenoside A_1, (4*R*,13*S**,16*S**)-1β-*trans*-cinnamoyloxy-6α-(β-D-glucopyranosyloxy)-16-methoxy-15,16-epoxy-18-neoclerodanal; scuterepenoside A_2, *cis*-cinnamoyl form of A_1; scuterepenoside A_3, (13*S**,16*R**)-form of A_1; scuterepenoside A_4, (13*S**,16*R**)-form of A_2; scuterepenin H, (5*S*,10*R*,13*S*,14*S*)-13-hydroxy-7-oxo-9,11-seco-8-abieten-14,11-olide.**

Key words *Scutellaria repens*; neoclerodane diterpene; secoabietane diterpene; scuterepenin; scuterepenoside; Lamiaceae

In a previous paper,[2] we reported the structural identification of seven flavonoids and seven phenylethanoids isolated from the root of *Scutellaria repens* (Lamiaceae). In the course of our studies on Nepalese crude drugs[1] and on the constituents of *Scutellaria* species,[3] we have investigated the dried leaves of this plant. This paper deals with the isolation and structural elucidation of the neoclerodane and secoabietane diterpenoids from this plant.

Repeated chromatography of the ether-soluble fraction of the methanol extract of the material gave seventeen new diterpenoids, as described in the experimental section.

Scuterepenin A_1 (**1**) was obtained as a white powder and showed IR absorption bands at 3456 (OH), 1712 (C=O) and 1638 cm^{-1} (aromatic C=C). The molecular formula was deduced to be $C_{29}H_{38}O_9$ from the FAB-MS and ^{13}C-NMR spectral data. Twenty-nine carbon signals were observed in the ^{13}C-NMR spectrum and their multiplicities were determined based on the distortionless enhancement by polarization transfer (DEPT) spectrum. The presence of a *trans*-cinnamoyl group was deduced from the ^{1}H- and ^{13}C-NMR spectra which showed characteristic signals (Tables 1 and 2). This was also supported by the UV spectrum which showed absorption peaks at 277, 222, 216 and 205 nm. The ^{13}C-NMR spectrum showed signals due to three methyls (δ 15.1, 14.4, 12.0), six methylenes (δ 68.6, 66.4, 43.6, 41.2, 40.7, 33.0), six methines (δ 113.1, 86.6, 75.9, 75.7, 54.5, 40.6) and five quaternary carbons (δ 211.1, 87.3, 77.5, 49.5, 43.3), in addition to those assignable to a cinnamoyl moiety. From these data, **1** was suggested to be a diterpenoid. The presence of fifteen partial structures was suggested from the ^{1}H–^{1}H shift correlation spectroscopy (COSY) and ^{1}H–^{13}C COSY data, and then the sequence was clarified based on the ^{1}H–^{13}C long-range COSY spectrum as shown in Fig. 1. The presence of a hydroxytetrahydrofurofuran ring was also supported by the characteristic MS fragment at *m/z* 129 ($C_6H_9O_3$).

The relative stereochemistry of the decaline moiety of **1** was determined as follows. Both H-6 and H-7 were deduced as being axial from the $J_{H\text{-}6,H\text{-}7}$ value (9.5 Hz). In the difference nuclear Overhauser effect (DIFNOE) spectrum, irradiation of H_3-19 enhanced the intensities of the H-7 and H_3-20 signals, whereas irradiation of H-10 enhanced those of the H-6, H-8 and H_2-18 signals. In addition, nuclear Overhauser effects (NOEs) were observed between H-11 and H-15α, indicating that the relative stereochemistry of the hydroxyhexahydrofurofuran moiety was 11*S**, 13*S**, 16*S**, because NOEs between H-11 and H-15α were observed only when the hydroxyhexahydrofurofuran moiety was the (11*S**, 13*S**, 16*S**)-type and it assumed an end-type conformation among the various possible stereostructures, as deduced from consideration of Büchi Dreiding stereomodels.

From these findings, the relative stereochemistry of **1** is as shown in Chart 1.

The 5*R* configuration was suggested, by applying the Octant rule,[4] from the circular dichroism (CD) spectrum of **1** showing a negative Cotton effect at 299 nm ($\Delta\varepsilon = -3.0$)(Fig. 2). Furthermore, the CD spectrum of the 6, 13, 18-tri-*O*-*trans*-cinnamate (**1a**) of **1** showed a negative first Cotton effect at 290 nm ($\Delta\varepsilon = -46.9$) and a positive second one at 261 nm ($\Delta\varepsilon = +55.0$). By applying the exciton chirality rule[5] to this result, an *R*-configuration was assigned to both the C-6 and C-7 positions.

The absolute configuration of the hydroxyhydrofuro-

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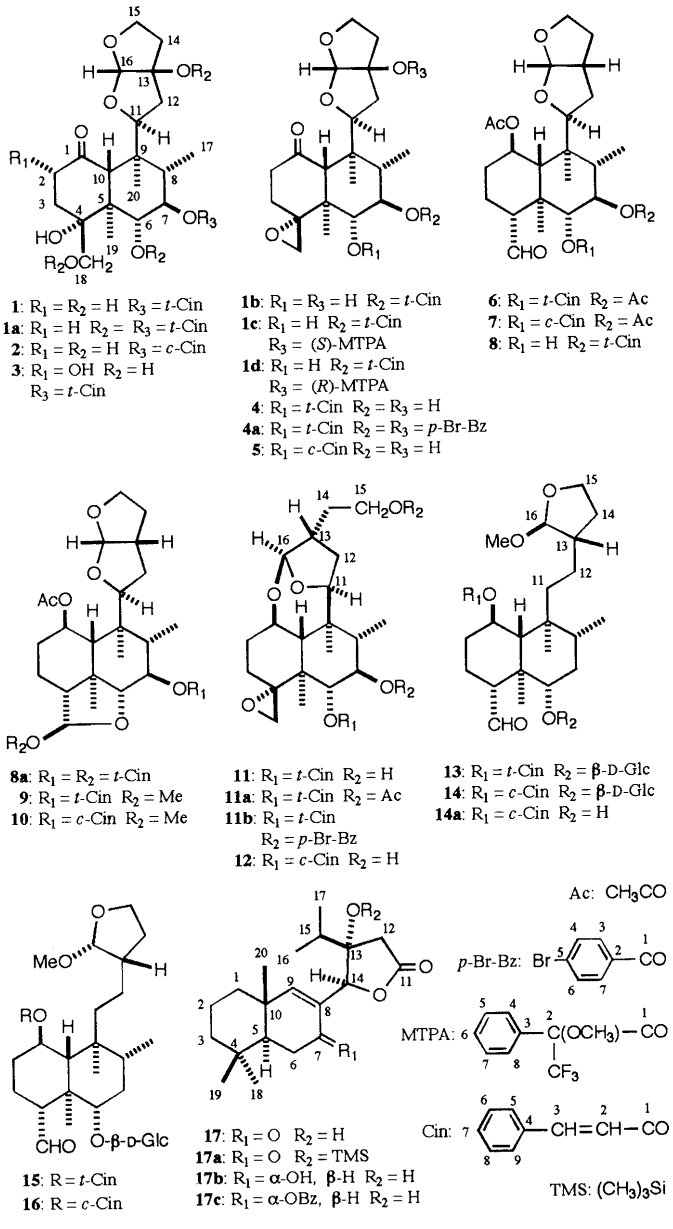
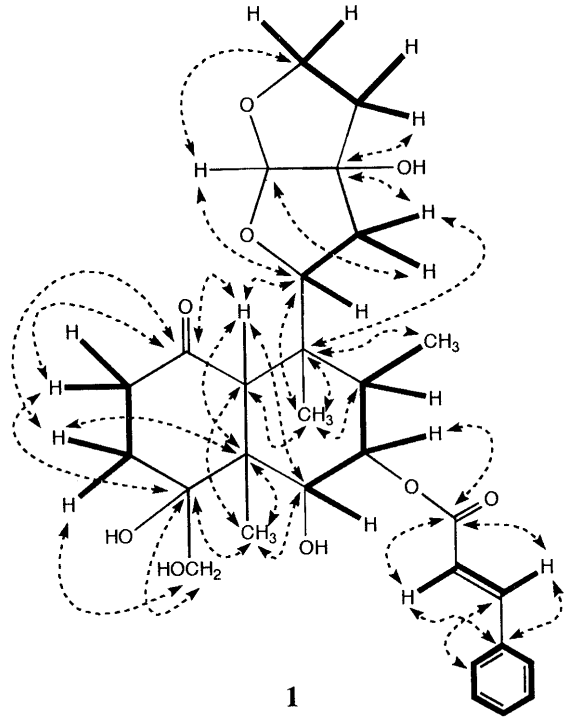


Chart 1



1

Fig. 1. Gross Planar Structure of **1**

Partial structures deduced from ^{1}H–^{1}H-COSY are depicted with bold lines. ^{1}H–^{13}C long-range correlations observed in ^{1}H–^{13}C long-range COSY are shown by curved arrows.

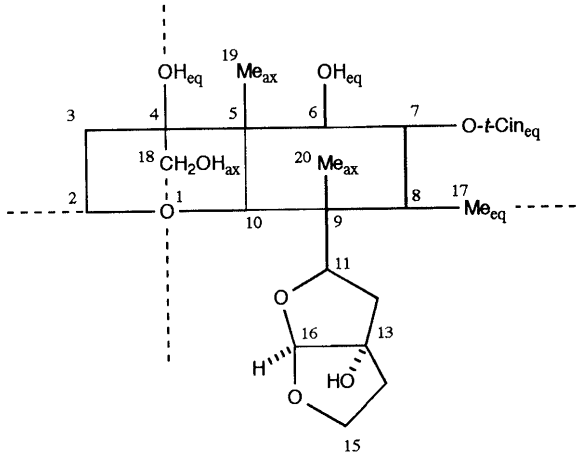


Fig. 2. Octant Projection of **1**

furan moiety was determined by the advanced Mosher method.[6] After conversion from **1** to its 4,18-epoxide (**1b**) by treatment with *p*-toluenesulfonyl chloride in a triethylamine solution, 13-*O*-(*R*)- and 13-*O*-(*S*)-methoxy-(trifluoromethyl)phenylacetyl (MTPA) ester (**1c** and **1d**, respectively) were prepared and submitted to ^{1}H-NMR spectroscopy. The $\Delta\delta$ value ($\delta_{(S)\text{-MTPA (1c)}} - \delta_{(R)\text{-MTPA (1d)}}$) of each proton is shown in Fig. 3, indicating that the absolute configuration at C-13 should be *R*.

On the basis of these results, the structure of scuterepenin A_1 (**1**) was concluded to be (4*R*,11*S*,13*R*)-7β-*trans*-cinnamoyloxy-4,6α,13,18-tetrahydroxy-11,16 : 15, 16-diepoxy-1-neoclerodanone.

From the NMR (Tables 3 and 4) and CD spectral data ($\Delta\varepsilon_{299\text{ nm}} = -2.1$), scuterepenin A_2 (**2**) was easily deduced to be a compound in which the *trans*-cinnamoyl group in **1** was replaced with a *cis*-cinnamoyl group.

Scuterepenin B (**3**) showed a very similar signal pattern to that of **1** in the ^{13}C-NMR spectrum. However, in contrast to **1**, one more oxygenated-methine signal was observed instead of a methylene one. The molecular formula was determined as $C_{29}H_{38}O_9$ from the FAB-MS and ^{13}C-NMR spectral data. Consequently, **3** was deduced to be a compound in which the hydrogen in **1** was replaced by a hydroxyl group. Most of the ^{13}C signals, except for A ring carbons, corresponded to those of **1**. The signal assignable to C-10 (δ 50.7) was observed upfield by 3.8 ppm compared with that of **1**, suggesting that an additional hydroxyl group was located at the C-2 position. This was confirmed from the ^{1}H–^{1}H, ^{1}H–^{13}C, and ^{1}H–^{13}C long-range COSY spectral data. The configuration of H-2 was deduced to be β-axial from the $J_{\text{H-2,H-3}\alpha}$ value (13 Hz). Obvious NOEs between H-2 and H-10 also supported this. The relative stereochemistry was confirmed by NOE experiments which gave the same results as for **1**.

The absolute configuration of **3** was confirmed to be

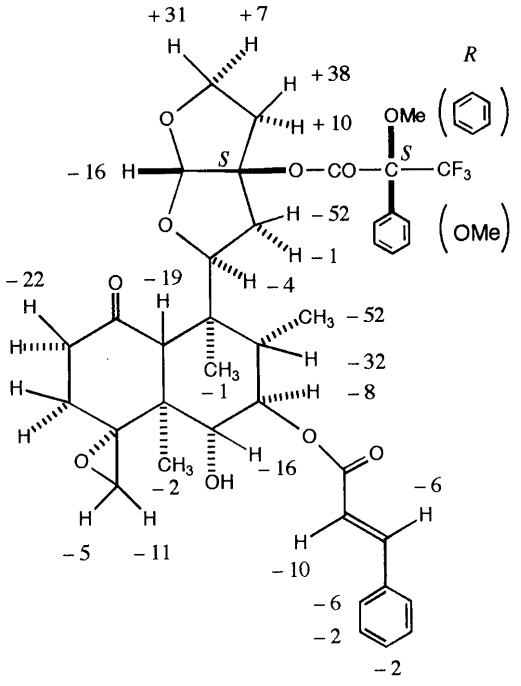


Fig. 3. Chemical Shift Differences between **1c** and **1d**

$\Delta\delta$ values ($\Delta\delta = \delta_{(S)\text{-MTPA (1c)}} - \delta_{(R)\text{-MTPA (1d)}}$) are shown in Hz.

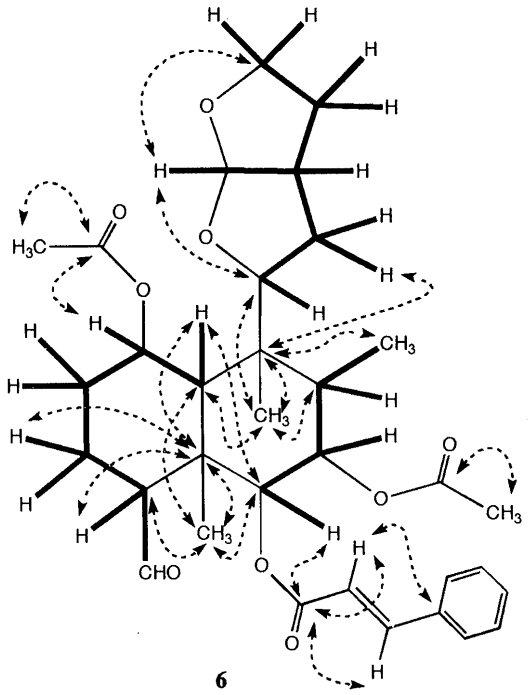


Fig. 4. Gross Planar Structure of **6**

Partial structures deduced from ^{1}H–^{1}H-COSY are depicted with bold lines. ^{1}H–^{13}C long-range correlations observed in ^{1}H–^{13}C long-range COSY are shown by dotted curved arrows.

the same as **1** based on the CD spectrum: a negative Cotton effect was observed at 295 nm ($\Delta\varepsilon = -2.8$).

From these results, the structure of scuterepenin B (**3**) was concluded to be (4*R*,11*S*,13*R*)-7β-*trans*-cinnamoyloxy-2α,4,6α,13,18-pentahydroxy-11,16 : 15,16-diepoxy-1-neoclerodanone.

In its NMR spectra, scuterepenin C_1 (**4**) showed characteristic signals due to a 2,2-disubstituted oxirane ring [δ_C 65.1 (quaternary), 52.5 (methylene); δ_H 3.76 (dd, J=4, 2 Hz), 2.48 (d, J=2 Hz)] in addition to a carbonyl group (δ_C 209.5), a *trans*-cinnamoyl group and a hydroxyhydrofurofuran moiety (Tables 1 and 2). The ^{1}H-NMR spectrum of **4** was very similar to that of **1b** except that the H-6 signal appeared downfield (δ 5.38) and the H-7 signal was upfield (δ 3.91). Therefore, **4** was deduced to be a 6-*O*-*trans*-cinnamoyl derivative. The relative stereochemisry was confirmed by NOE experiments which gave compatible results with **1b**. The absolute configuration was suggested to be the same as **1** based on the CD spectral data ($\Delta\varepsilon_{296\,nm} = -4.1$) and it was confirmed by the CD spectrum of the 7,13-di-*O*-*p*-bromobenzoate (**4a**), which showed a negative first Cotton effect at 272 nm ($\Delta\varepsilon = -23.5$) and a positive second one at 245 nm ($\Delta\varepsilon = +26.2$).

Based on these findings, the structure of scuterepenin C_1 (**4**) was concluded to be (4*R*,11*S*,13*R*)-6α-*trans*-cinnamoyloxy-7β,13-dihydroxy-4,18 : 11,16 : 15,16-triepoxy-1-neoclerodanone.

Scuterepenin C_2 (**5**) was easily deduced to be a compound in which the *trans*-cinnamoyl group in **4** was replaced by a *cis*-cinnamoyl one from the ^{1}H- and ^{13}C-NMR data (Tables 1 and 2) as well as from the CD data ($\Delta\varepsilon_{297\,nm} = -2.7$).

Scuterepenin D_1 (**6**) was suggested to be a diterpenoid possessing an aldehyde [δ_C 201.6; δ_H 9.70 (d, J=5 Hz)], two acetyl, two *tert*-methyl and a *trans*-cinnamoyl group from the NMR spectral data (Tables 1 and 2). The presence of a hydrofurofuran ring was suggested from the characteristic electron impact (EI)-MS fragment ion at m/z 113 ($C_6H_9O_2$). The IR spectrum showed an absorption band due to a carbonyl group at 1742 cm^{-1}, but no absorption band due to a hydroxyl group. The molecular formula was determined as $C_{33}H_{42}O_9$ based on the FAB-MS and ^{13}C-NMR spectral data.

The ^{1}H–^{1}H and ^{1}H–^{13}C COSY spectra indicated the presence of three partial structures, and the sequence, including linking positions of the acyl groups, was obtained from ^{1}H–^{13}C long-range COSY spectral data (Fig. 4).

The relative stereochemistry was determined by the NOE experiments in addition to the coupling constant of each proton. NOEs were observed as follows: between H_3-19 and H-1, H-3α, H-7, H-18 and H_3-20; between H-10 and H-2β, H-4, H-6 and H-8; between H-11 and H-15α.

From the above results, the structure of scuterepenin D_1 (**6**) was deduced to be (4*R*,11*S**,13*R**)-6α-*trans*-cinnamoyloxy-1β,7β-diacetoxy-11,16 : 15,16-diepoxy-18-neoclerodanal.

From the ^{1}H- and ^{13}C-NMR data, scuterepenin D_2 (**7**) proved to be a compound in which the *trans*-cinnamoyl group in **6** was replaced with a *cis*-cinnamoyl one (Tables 1 and 2).

Scuterepenin E (**8**) showed an absorption band due to a hydroxy group (3464 cm^{-1}) together with carbonyl groups (1732, 1716 cm^{-1}). The ^{1}H- and ^{13}C-NMR spectra (in $CDCl_3$, Tables 3 and 4) of **8** showed the presence of an acetyl group and were similar to those of **6** except for signals assignable to C-4 - C-7, C-18, C-19, H-6, H-7, H_3-18 and H_3-19, suggesting that **8** was related to **6**. The molecular formula was determined as $C_{31}H_{40}O_8$ based on the FAB-MS and ^{13}C-NMR spectral data. A proton

Table 1. ^{1}H-NMR Spectral Data for **1**, **1a**—**1d**, **3**, **4**, **4a**, **5**—**7**, **8a**, **11**, **11a** and **12** (Pyridine-d_5)[a)]

H No.	1	1a	1b	1c[b)]	1d[c)]	3	4	4a[d)]
1	—	—	—	—	—	—	—	—
2β	2.89 ddd (13, 13, 6.5)	3.06 ddd (13.5, 13.5, 6.5)	2.55 m	2.52 m	2.58 m	5.09 dd (13, 7)	2.56 m	Overlapped
2α	2.33 ddd (13, 4.5, 2)	2.41 m	Overlapped	2.39 m	2.40 m	—	2.36 m	Overlapped
3β	2.55 ddd (13, 6.5, 2)	2.61 m	1.41 m	1.42 m	1.42 m	3.15 dd (13, 7)	1.29 m	1.34 m
3α	2.19 ddd (13, 13, 4.5)	2.27 ddd (14, 14, 5)	Overlapped	2.39 m	2.40 m	2.40 dd (13, 13)	2.39 m	Overlapped
4	—	—	—	—	—	—	—	—
6	4.79 dd (9.5, 2)	6.10 d (10)	4.02 d (9.5)	3.96 dd (9, 2.5)	4.00 dd (9.2)	4.86 d (9.5)	5.38 d (9)	5.62 d (10)
7	5.69 dd (11, 9.5)	5.78 dd (11.5, 9.5)	5.56 dd (11.5, 9.5)	5.53 dd (11.5, 9)	5.55 dd (11, 9.5)	5.72 dd (11, 9.5)	3.91 dd (12, 9)	5.72 dd (11.5, 10)
8	2.35 m	2.16 dq (11.5, 6.5)	Overlapped	2.25 dq (11.5, 6.5)	2.33 dq (11, 6.5)	2.26 dq (11, 6.5)	2.25 dq (12, 6.5)	Overlapped
10	3.88 s	3.74 s	3.36 s	3.25 s	3.29 s	4.13 s	3.41 s	3.53 s
11	4.69 dd (12, 6)	4.69 dd (10, 7)	4.67 dd (12, 5.5)	4.70 dd (12, 5.5)	4.71 dd (12, 5.5)	4.59 dd (12, 5)	4.64 dd (12, 5.5)	4.73 dd (11.5, 5.5)
12β	2.67 dd (12, 12)	2.73 m	2.64 dd (12, 12)	2.54 dd (13.5, 12)	2.67 dd (13, 12)	2.70 dd (12, 12)	2.67 dd (12, 12)	2.76 dd (13, 11)
12α	2.35 m	2.73 m	Overlapped	2.94 dd (13.5, 5.5)	2.94 dd (13, 5.5)	2.34 dd (12, 5)	2.36 dd (12, 5.5)	2.95 dd (13, 5.5)
13	—	—	—	—	—	—	—	—
14β	2.38 ddd (12.5, 7.5, 7.5)	2.50 ddd (13, 8, 8)	Overlapped	2.54 m	2.44 ddd (13.5, 8, 8)	2.35 m	2.41 m	Overlapped
14α	2.21 ddd (12.5, 7, 5)	2.60 m	2.20 ddd (12.5, 7, 5)	2.66 m	2.63 ddd (13.5, 5.5, 5.5)	2.17 ddd (12, 7, 5)	2.22 m	Overlapped
15β	4.09 ddd (8.5, 7.5, 5)	4.05 m	4.12 ddd (8.5, 8, 5)	4.02 ddd (8, 8, 4.5)	3.95 dd (8, 5.5)	4.02 ddd (8.5, 8, 5)	4.11 ddd (8, 8, 5.5)	4.07 m
15α	4.02 ddd (8.5, 7.5, 7)	4.05 m	4.02 ddd (8.5, 7, 7)	3.96 ddd (8, 8, 8)	3.95 dd (8, 5.5)	3.94 ddd (8.5, 7, 7)	4.03 ddd (8, 7.5, 7.5)	4.07 m
16	5.84 s	6.13 s	5.85 s	5.94 s	5.98 s	5.74 s	5.83 s	6.21 s
17	1.18 d (6.5)	1.12 d (6.5)	1.19 d (6.5)	1.04 d (6.5)	1.14 d (6.5)	1.16 d (6.5)	1.44 d (6.5)	1.01 d (6.5)
18A	4.66 br d (11.5)	5.64 d (11.5)	3.65 dd (4, 2)	3.65 m	3.67 m	4.73 br d (11.5)	3.76 dd (4, 2)	3.80 br d (4)
18B	4.59 br d (11.5)	5.62 d (11.5)	2.72 d (4)	2.75 d (3.5)	2.76 d (3.5)	4.61 br d (11.5)	2.48 d (4)	2.59 d (4)
19	1.66 s	1.78 s	1.43 s	1.42 s	1.42 s	1.69 s	1.52 s	1.54 s
20	1.73 s	1.81 s	1.57 s	1.52 s	1.52 s	1.89 s	1.64 s	1.65 s
6(or 7)-OH	7.42 d (2)	—	—	4.75 d (2.5)	4.76 d (2)	—	—	—
Cin-2	6.58 d (16)	6.82, 6.78, 6.77, 6.64 each 1H, d (16)	6.85 d (16)	6.85 d (16)	6.88 d (16)	6.59 d (16)	6.76 d (16)	6.65 d (16)
Cin-3	7.86 d (16)	8.07, 8.02, 7.87, 7.85 each 1H, d (16)	8.00 d (16)	8.02 d (16)	8.03 d (16)	7.87 d (16)	7.88 d (16)	7.78 d (16)
Cin-5, 9	7.49 m	7.16—7.68	7.60 m	7.61 m	7.62 m	7.49 m	7.49 m	7.38 m
Cin-6, 8	7.33 m	7.16—7.68	7.35 m	7.35 m	7.35 m	7.34 m	7.30 m	7.22 m
Cin-7	7.33 m	7.16—7.68	7.35 m	7.35 m	7.35 m	7.34 m	7.30 m	Overlapped
Ac	—	—	—	—	—	—	—	—
Ac	—	—	—	—	—	—	—	—

Table 1. Continued

H No.	5	6	7	8a	11	11a	12
1	—	5.36 ddd (10, 10, 4)	5.32 ddd (10.5, 10.5, 4)	5.39 ddd (10.5, 10.5, 5.5)	4.20 ddd (10, 9, 6.5)	4.15 ddd (9.5, 8.5, 6)	4.16 ddd (9.5, 8.5, 6)
2β	2.54 m	1.43 m	1.42 m	1.62 m	1.79 m	1.78 m	1.78 m
2α	2.32 m	2.05 m	2.05 m	2.28 m	2.19 m	2.17 m	2.18 m
3β	1.27 m	1.30 m	1.27 m	1.34 m	0.91 m	0.92 m	0.91 m
3α	2.38 m	1.76 dddd (13, 13, 13, 5)	1.72 dddd (13, 13, 13, 5)	1.62 m	2.20 m	2.19 m	2.20 m
4	—	2.28 ddd (13, 5, 5)	2.18 ddd (13, 5, 5)	2.18 ddd (12, 7, 5)	—	—	—
6	5.28 d (9)	5.36 d (10.5)	5.23 d (10.5)	4.19 d (10)	5.20 d (9)	5.22 d (10)	5.12 d (9)
7	3.82 br ddd (11, 9, 6)	5.46 dd (10.5, 10.5)	5.37 dd (10.5, 10.5)	5.68 dd (10, 9)	3.91 m	5.50 dd (10.5, 10)	3.85 m
8	2.23 dq (11, 6.5)	2.47 dq 10.5, 6.5)	2.44 dq (10.5, 6.5)	2.50 dq (9, 7)	1.68 dq (10.5, 6.5)	1.65 m	1.63 m
10	3.36 s	2.59 d (10)	2.54 d (10.5)	2.80 d (11)	1.75 d (9)	1.75 m	1.70 d
11	4.62 dd (12, 5.5)	4.68 dd(11.5, 5)	4.67 dd (12, 4.5)	4.44 dd (11.5, 4.5)	4.40 dd (8, 7)	4.29 dd (8.5, 6.5)	4.38 dd (8, 6.5)
12β	2.66 dd (12, 12)	1.82 ddd (11.5, 11, 8.5)	1.81 ddd (12, 12, 9)	1.79 ddd (11.5, 11.5, 8)	2.08 ddd (14, 7, 7)	2.06 ddd (12.5, 7.5, 6.5)	2.03 m
12α	2.35 dd (12, 5.5)	1.57 m	Overlapped	1.63 dd (11.5, 4.5)	1.60 dd (14, 8)	1.53 dd (12.5, 8.5)	1.56 m
13	—	2.75 m	2.74 m	2.77 m	2.62 m	2.39 br ddd (7.5, 7.5, 7.5)	2.60 br ddd (7.5, 7.5, 7.5)
14β (14A)	2.40 ddd (12.5, 7.5, 7.5)	2.03 m	2.01 m	2.05 m	1.85 ddt (14, 7, 7)	1.73 ddt (14, 7, 7)	1.84 m
14α (14B)	2.20 ddd (12.5, 7, 5)	1.59 m	Overlapped	1.62 m	1.64 m	1.48 ddt (14, 8, 6.5)	1.61 m
15β (15A)	4.10 ddd (9, 7.5, 5)	3.85 ddd (8.5, 8.5, 5)	3.85 ddd (8, 8, 4.5)	3.92 ddd (8.5, 8.5, 4.5)	3.91 m	4.19 dd (7, 6.5)	3.91 m
15α (15B)	4.01 ddd (9, 7.5, 7)	4.01 ddd (8.5, 8, 7)	4.01 ddd (8, 8, 8)	4.07 ddd (8.5, 8.5, 8.5)	3.91 m	4.19 dd (7, 6.5)	3.91 m
16	5.82 s	5.80 d (5)	5.81 d (5)	5.94 d (5)	5.34 s	5.21 s	5.32 s
17	1.43 d (6.5)	1.01 d (6.5)	0.99 d (6.5)	1.17 d (7)	1.25 d (6.5)	0.87 d (6.5)	1.24 d (6.5)
18A	3.69 dd (4, 2)	9.70 d (5)	9.58 d (5)	6.53 d (7)	3.65 dd (4, 2)	3.56 dd (4, 2)	3.58 dd (4, 2)
18B	2.47 d (4)	—	—	—	2.40 d (4)	2.43 d (4)	2.40 d (4)
19	1.39 s	1.49 s	1.34 s	0.94 s	1.52 s	1.49 s	1.40 s
20	1.59 s	1.02 s	0.99 s	1.03 s	1.38 s	1.35 s	1.33 s
6(or 7)-OH	6.60 d (6)	—	—	—	6.59 d (7)	—	6.57 br d (7)
Cin-2	6.20 d (12.5)	6.75 d (16)	6.00 d (13)	6.64, 6.74 each 1H, d (16)	6.76 d (16)	6.80 d(16)	6.23 d (12.5)
Cin-3	6.91 d (12.5)	7.95 d (16)	7.04 d (13)	7.90, 7.96 each 1H, d (16)	7.87 d (16)	7.96 d (16)	6.89 d (12.5)
Cin-5, 9	7.91 m	7.52 m	7.92 br d (7.5)	7.48, 7.63 each 2H m	7.48 m	7.52 m	7.92 m
Cin-6, 8	7.31 m	7.33 m	7.41 br t (7.5)	7.29—7.34	7.29 m	7.30 m	7.30 m
Cin-7	7.25 m	7.30 m	7.33 br t (7.5)	7.29—7.34	7.29 m	7.30 m	7.25 m
Ac	—	2.10 s (1-*O*-Ac)	2.09 s (1-*O*-Ac)	2.11 s (1-*O*-Ac)	—	2.00 s	—
Ac	—	2.00 s (7-*O*-Ac)	1.95 s (7-*O*-Ac)	—	—	2.07 s	—

a) Coupling constants (*J*) in Hz are given in parentheses. *b*) MTPA part: 3.63 s (OMe), 7.38 br t (7.5) (H-6), 7.44 br t (7.5) (H-5, 7), 7.76 br d (7.5) (H-4, 8). *c*) MTPA part: 3.60 s (OMe), 7.41 br t (7.5) (H-6), 7.46 br t (7.5) (H-5, 7), 7.76 br d (7.5) (H-4, 8). *d*) *p*-Bromobenzoyl part: 7.55, 7.64 each m (H-4, 6), 7.98, 8.05 each m (H-3, 7).

Table 2. ^{13}C-NMR Spectral Data for **1**, **1a**—**1d**, **3**, **4**, **4a**, **5**—**7**, **8a**, **11**, **11a** and **12** (Pyridine-d_5)

C No.	**1**	**1a**	**1b**	**1c**[a]	**1d**[b]	**3**	**4**	**4a**[c]	**5**	**6**	**7**	**8a**	**11**	**11a**	**12**
1	211.1	209.7	209.4	209.5	209.5	212.1	209.5	208.9	209.5	71.6	71.6	72.0	67.5	67.4	67.5
2	41.2	41.1[d]	41.7	41.7[d]	41.9	73.3	42.3	42.0	42.3	31.3	31.3	32.9	32.5	32.3	32.5
3	33.0	33.4	31.6	31.3	31.3	44.5	32.2	31.7	32.1	20.9	20.9	20.1	29.6	29.3	29.6
4	77.5	76.1	66.3	66.2	66.2	77.0	65.1	65.0	65.1	58.9	58.9	55.9	67.3	67.1	67.3
5	49.5	50.5	45.3	45.2	45.2	49.8	45.4	45.3	45.2	44.5	44.2	46.4	41.7[d]	41.8[d]	41.6[d]
6	75.9	75.1	75.2[d]	75.0[e]	74.9[d]	75.9	77.8	74.2[d]	77.6	79.3	78.8	86.1	79.2	75.7[e]	78.9
7	75.7	73.4	75.1[d]	74.7[e]	74.7[d]	75.4	70.6	74.4[d]	70.4	74.9	74.8	77.3	72.3	74.9[e]	72.2
8	40.6	40.3	39.9	39.6	39.7	41.3	42.3	40.2	42.4	37.1	37.1	38.0	42.7	40.3	42.9
9	43.3	43.4	42.9	42.7	42.7	43.7	42.7	43.0	42.7	42.9	42.8	45.1	43.2[d]	43.2[d]	43.2[d]
10	54.5	53.8	57.5	58.0	58.0	50.7	57.4	57.8	57.6	51.1	50.9	48.9	53.7	53.5	53.7
11	86.6	86.9	85.6	85.5	85.5	87.1	86.3	86.0	86.2	84.6	84.6	85.8	88.1	87.6	88.0
12	43.6	41.3[d]	43.6	41.6[d]	41.6	43.2	43.3	41.6	43.3	34.4	34.3	33.6	27.6	27.1	27.6
13	87.3	93.7	87.4	95.9	96.0	87.5	87.3	94.3	87.3	42.7	42.7	42.9	46.0	45.8	46.0
14	40.7	39.1	40.8	38.5	38.3	40.7	40.8	38.7	40.8	32.2	32.2	32.1	35.4	30.6	35.4
15	68.6	68.4	68.7	68.7	68.6	68.4	68.6	68.8	68.6	68.3	68.3	68.5	60.4	62.8	60.4
16	113.1	110.8	113.2	110.8	110.7	113.1	113.2	111.0	113.2	108.3	108.3	108.6	102.4	102.1	102.4
17	12.0	11.3	12.0	11.8	11.9	11.5	12.0	11.4	12.0	16.0	16.1	18.0	11.0	10.6	11.0
18	66.4	67.7	52.8	52.8	52.8	68.3	52.5	52.5	52.4	201.6	201.6	100.5	51.9	51.8	51.8
19	14.4	14.9[e]	16.7	17.0	17.0	14.1	17.3	17.4	17.2	12.4	12.2	12.1	19.6	19.3[f]	19.4
20	15.1	15.2[e]	14.3	14.0	14.0	16.0	14.7	14.2	14.5	16.2	16.2	17.3	20.2	19.9[f]	20.2
1-*O*-Ac										169.8	169.8	170.2		170.7	
										21.7	21.6	21.5		20.8	
7(15)-*O*-Ac										170.7	170.6			170.7	
										20.8	20.8			20.8	
Cin-1	167.0	167.1	167.0	166.9	167.0	167.0	166.2	165.9	166.5	165.8	164.5	166.9	166.3	165.9	165.8
		166.5										166.2			
Cin-2	119.3	119.6	119.5	119.4	119.4	119.2	120.2	118.7	121.3	118.3	119.1	118.6	120.6	119.4	121.8
		118.5										119.0			
Cin-3	144.6	145.9	144.8	144.9	145.0	144.6	144.1	145.3	142.0	146.1	145.8	145.2	143.6	144.8	141.5
		144.9										145.8			
Cin–4	134.9	134.8	135.1	135.0	135.1	134.9	135.1	134.7	135.7	134.7	135.2	134.9	135.2	134.9	135.3
		134.8										134.9			
Cin-5, 9	128.4	128.8	128.5	128.5	128.5	128.4	128.4	128.5	130.6	128.7	130.9	128.5	128.3	128.6	130.6
		128.4										129.2			
Cin-6, 8	129.2	129.4	129.3	129.1	129.1	129.2	129.2	129.1	128.3	129.2	128.4	128.7	129.1	129.2	128.3
		129.2										129.3			
Cin-7	130.5	130.9	130.6	130.6	130.6	130.6	130.3	130.5	129.1	130.8	129.7	130.6	130.2	130.5	129.0
		130.3										130.8			

a) MTPA part: 166.3, 132.4, 130.3, 129.3, 127.6, 123.1, *ca.* 86, 55.8. *b*) MTPA part: 166.3, 132.2, 130.4, 129.3, 127.8, 123.1, *ca.* 86, 55.6. *c*) *p*-Bromobenzoyl part: 165.9, 165.2, 132.2 (×4), 131.8 (×2), 131.7 (×2), 129.6, 129.2, 128.7, 128.6. *d*—*f*) May be interchanged in each column.

signal observed at 2.61 ppm as a broad doublet was deduced to be a hydroxyl proton which coupled with a signal at 3.48 ppm from the ^{1}H–^{1}H COSY spectrum. The position of an acetoxyl group was determined to be C-1 from the DIFNOE spectra in which obvious NOEs were observed between acetylmethyl protons and the H-11 and H-15α. Consequently, a *trans*-cinnamoyloxy group is at the C-7 position. Assignments of each of the proton and carbon signals were confirmed based on ^{1}H–^{1}H and ^{1}H–^{13}C COSY spectral data.

The relative stereochemistry was confirmed by the NOE experiments in which the following NOEs were observed: between H_3-19 and H-1, H-3α, H-7, H-18 and H_3-20; between H-6 and H-4, H-8 and H-10; between H-11 and H-10, H-15α and H_3-20.

Compound **8** was submitted to *trans*-cinnamoylation to give **8a**. The NMR spectrum (Tables 1 and 2) of **8a** showed signals due to two moles of a *trans*-cinnamoyl group and a hemiacetal ester (δ_C 100.5; δ_H 6.53) instead of an aldehyde group. Then, a signal due to C-6 (δ_C 86.1) was observed significantly downfield. These data suggested that **8a** was the 18-*trans*-cinnamoyloxy-6,18-epoxide derivative. The relative stereochemical structure was confirmed by NOE experiments: obvious NOEs were observed between H-18 (δ 6.53) and H_3-19 (δ 0.94) as well as between H-4 (δ 2.18) and H-6 (δ 4.19).

The CD spectrum of **8a** showed a positive first Cotton effect at 290 nm ($\Delta\varepsilon = +14.9$) and the negative second one at 262 ($\Delta\varepsilon = -13.1$). Therefore, the *S*- and *R*-configurations were assigned to the C-18 and C-7 positions, respectively.

On the basis of these results, the structure of scuterepenin E (**8**) was determined to be (4*R*,11*S**,13*R**)-1β-acetoxy-7β-*trans*-cinnamoyloxy-6α-hydroxy-11,16:15,16-diepoxy-18-neoclerodanal.

Scuterepenin F (**9**) was suggested to be a compound in which the 18-*O*-*trans*-cinnamoyl group of **8a** was replaced with a methoxyl group from comparisons of the NMR spectra (Tables 3 and 4). This was confirmed by the fact that treatment of **8** with 0.1 N HCl–MeOH gave **9**. The configuration at the C-18 position was confirmed by NOE experiments: obvious NOEs were observed between H-18 and H_3-19.

Consequently, scuterepenin F_1 (**9**) is (4*R*,11*S**,13*R**)-

Table 3. ^{1}H-NMR Spectral Data for **2**, **6**, **8**, **9** and **10** ($CDCl_3$)[a]

H No.	**2**	**6**	**8**	**9**	**10**
1α	—	5.19 ddd (10, 10, 4)	5.23 ddd (10.5, 10.5, 4)	5.16 ddd (10.5, 10.5, 5)	5.13 ddd (10.5, 10.5, 5)
2β	2.39 ddd (14.5, 13.5, 5.5)	1.61 m	1.60 m	1.42 dddd (13, 13, 10.5, 5.5)	1.40 ddd (13, 13, 10.5, 5)
2α	2.22 m	2.08 m	2.11 m	2.22 m	2.21 m
3β	2.16 m	1.50 m	1.53 m	1.74 m	1.72 m
3α	1.83 ddd (14, 14, 4.5)	1.86 m	1.87 m	1.64 m	1.62 m
4	—	2.27 m	2.21 m	1.78 m	1.77 m
6	3.96 d (9.5)	5.02 d (10)	3.48 dd (10, 5)	3.69 d (10.5)	3.57 d (10.5)
7	4.94 dd (11.5, 9.5)	5.12 dd (10.5, 10.5)	4.99 dd (11, 10)	5.21 dd (10.5, 8.5)	5.12 dd (10.5, 8.5)
8	1.96 dq (11.5, 6.5)	2.27 m	2.27 m	2.11 m	1.94 m
10	2.90 s	2.43 d (10.5)	2.25 d (10.5)	2.47 d (11.5)	2.40 d (11)
11	4.24 dd (11, 6)	4.56 dd (11.5, 5)	4.61 dd (11.5, 5)	4.23 dd (11.5, 5)	4.17 dd (11.5, 5)
12β	2.21 m	1.93 ddd (12, 11.5, 8.5)	1.96 m	1.85 m	1.79 ddd (12, 11.5, 8.5)
12α	2.1—2.2	*ca.* 1.6	1.59 m	*ca.* 1.6	1.58 dd (12, 5)
13	—	2.84 m	2.86 m	2.86 m	2.82 m
14β	2.1—2.2	2.16 m	2.18 m	2.17 m	2.14 m
14α	2.1—2.2	*ca.* 1.6	1.63 m	*ca.* 1.6	1.57 m
15β	4.02 ddd (9, 7.5, 5)	3.86 m	3.88 ddd (8, 8, 4.5)	3.90 m	3.88 m
15α	3.89 ddd (9, 7.5, 7.5)	3.92 m	3.94 ddd (8, 8, 7)	3.90 m	3.88 m
16	5.28 s	5.72 d (5)	5.73 d (5)	5.76 d (5)	5.64 d (5)
17	0.91 d (6.5)	0.94 d (6.5)	0.97 d (6.5)	1.06 d (7)	1.00 d (7)
18	4.07, 4.11, eqch d (11.5)	9.50 d (4)	9.64 d (5)	4.81 d (7)	4.82 d (7)
19	1.24 s	1.47 s	1.32 s	0.93 s	0.89 s
20	1.34 s	1.00 s	0.98 s	0.96 s	0.91 s
Ac	—	1.90 s, 2.04, s	2.05 s	2.03 s	2.01 s
OH	Not observed	—	2.61 br d (5.5)	—	—
OMe	—	—	—	3.39 s	3.43 s
Cin-2	6.01 d (12.5)	6.29 d (16)	6.46 d (16)	6.51 d (16)	6.00 d (12.5)
Cin-3	7.07 d (12.5)	7.61 d (16)	7.72 d (16)	7.72 d (16)	6.96 d (12.5)
Cin-5, 9	7.60 m	7.51 m	7.53 m	7.54 m	7.62 m
Cin-6, 8	7.38 m	7.37 m	7.39 m	7.38 m	7.33 m
Cin-7	7.38 m	7.37 m	7.39 m	7.38 m	7.33 m

a) Coupling constants (J) in Hz are given in parentheses.

Table 4. ^{13}C-NMR Spectral Data for **2**, **6**, **8**, **9** and **10** ($CDCl_3$)

C No.	**2**	**6**	**8**	**9**	**10**
1	210.1	71.7	72.0	72.3	72.3
2	40.2	31.0	31.4	32.7	32.7
3	30.3	20.8	20.9	20.1	20.1
4	77.2	58.5	59.8	56.1	56.0
5	48.3	44.4	46.0	45.8	45.8[a]
6	76.2	78.5	79.0	84.0	83.7
7	75.2	74.4	77.7	77.4	77.5
8	38.9	36.6	36.5	37.3	36.9
9	42.5	42.7	42.7	44.6	44.6[a]
10	54.7	50.7	50.9	48.4	48.3
11	85.0	84.3	84.3	85.6	85.6
12	42.8	34.3	34.5	33.4	33.3
13	87.7	42.3	42.3	42.5	42.4
14	40.3	32.1	32.2	32.1	32.1
15	68.3	68.0	68.1	68.2	68.1
16	112.0	107.9	108.0	108.3	108.2
17	11.8	15.8	15.9	17.8	18.0
18	64.1	201.2	202.4	108.2	108.1
19	13.7	12.5	11.4	12.5	12.4
20	14.5	16.2	16.0	17.3	17.3
Ac		169.7	169.7	170.2	170.2
		21.7	21.8	21.6	21.6
		170.9			
		20.9			
Cin-1	167.1	165.5	168.3	167.1	166.3
Cin-2	119.0	117.0	117.5	118.5	120.1
Cin-3	145.5	146.2	146.0	144.9	142.9
Cin-4	134.7	134.1	134.2	134.6	134.9
Cin-5, 9	129.8	128.4	128.2	128.1	129.9
Cin-6, 8	128.1	128.8	129.0	128.9	127.9
Cin-7	129.4	130.6	130.6	130.2	129.0

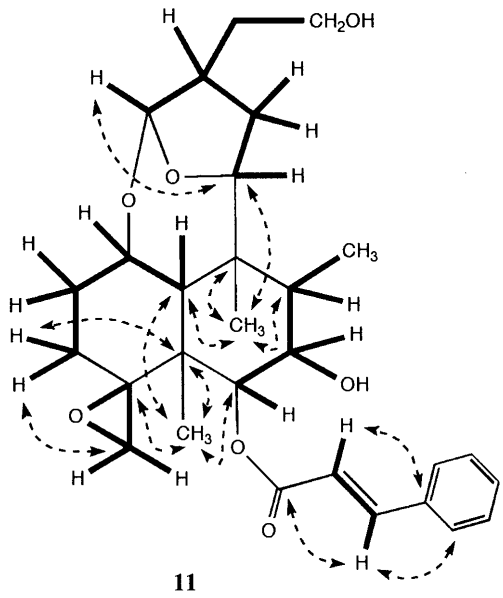
a) May be interchanged.

1β-*O*-acetyl-7β-*O*-*trans*-cinnamoyl-18β-*O*-methyl-6α,18 : 11,16 : 15,16-triepoxyneoclerodane-1,7,18-triol.

Scuterepenin F_2 (**10**) was deduced to be the 7β-*O*-*cis*-cinnamoyl form of **9** from comparisons of the NMR data (Tables 3 and 4).

Scuterepenin G_1 (**11**) showed IR absorption bands at 3464 (OH) and 1712 cm^{-1} (ester). The presence of a 1,1-disubstituted oxirane ring and a *trans*-cinnamoyl group was deduced from the NMR spectra (Tables 1 and 2). The molecular formula was determined to be $C_{29}H_{38}O_7$ based on the FAB-MS and ^{13}C-NMR spectral data. The ^{1}H–^{1}H and ^{1}H–^{13}C COSY spectra suggested the presence of four partial structures in addition to two *tert*-methyls and a *trans*-cinnamoyl group (Fig. 5). The C-15 signal of **11** appeared considerably upfield compared with that of the hydrofurofuran-bearing compound, indicating that a hydroxyl group was present at the C-15 position in **11**. This was supported by the ^{1}H-NMR spectrum of the diacetate (**11a**), in which the H_2-15 was observed downfield by 0.28 ppm compared with that of **11**. Furthermore, from the acylation shift, the other hydroxyl group should be connected to the C-7. From these data, the gross planar structure of **11** is as shown in Fig. 4.

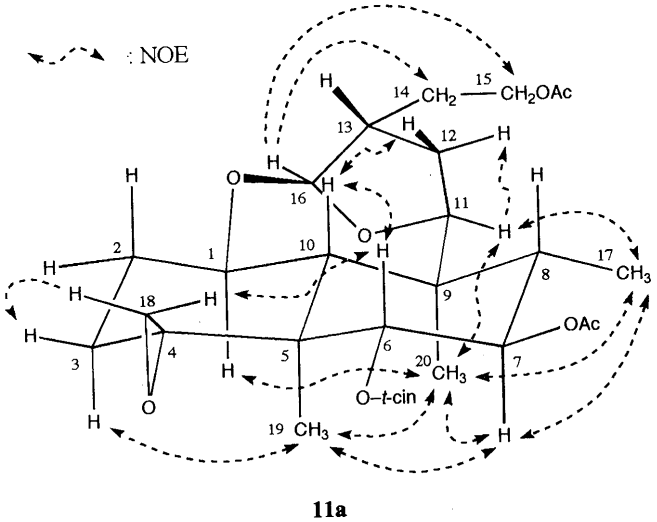
The relative stereochemistry was determined based on the results of NOE experiments as well as the J value of each proton. In the DIFNOE spectrum of **11a** in which the H-10 was irradiated, enhancement of the signal intensity of H-12β (δ 1.53, dd, J=12.5, 8.5 Hz) was clearly observed. However, irradiation of H-12β did not enhance



11

Fig. 5. Gross Planar Structure of **11**

Partial structures deduced from ^{1}H–^{1}H-COSY are depicted with bold lines. ^{1}H–^{13}C long-range correlations observed in ^{1}H–^{13}C long-range COSY are shown by dotted curved arrows.



11a

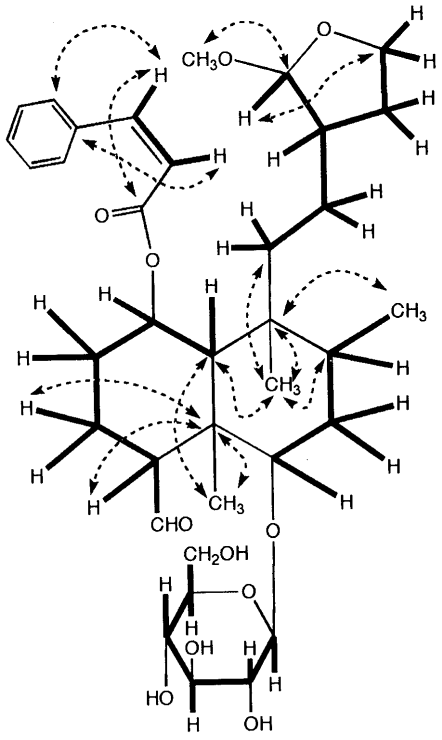
Fig. 6

the signal intensities of H-14A, H-14B and H_2-15, indicating that an acetoxyethyl group at the C-13 position adopted an α configuration. Based on these results and other observed NOEs, the relative stereochemistry of **11** was as shown in Fig. 6.

The CD spectrum of the *p*-bromobenzoate (**11b**) of **11** showed negative exiton chirality ($\Delta\varepsilon_{269\,nm} = -27.2$, $\Delta\varepsilon_{243\,nm} = +25.7$), denoting that the absolute stereochemistry of both C-6 and C-7 positions was the *R* form.

On the basis of these facts, the structure of scuterepenin G_1 (**11**) was concluded to be (4*R*,7*R*,11*S*,13*R*)-6α-*O*-*trans*-cinnamoyl-1,16 : 4,18 : 11,16-triepoxyneoclerodane-6,7,15-triol.

Scuterepenin G_2 (**12**) was deduced to be the 6α-*O*-*cis*-cinnamoyl form of **11** by ^{1}H- and ^{13}C-NMR spectral data and NOE experiments, the latter giving the same results as **11**.



14

Fig. 7. Gross Planar Structure of **14**

Partial structures deduced from ^{1}H–^{1}H-COSY are depicted with bold lines. ^{1}H–^{13}C long-range correlations observed in ^{1}H–^{13}C long-range COSY are shown by dotted curved arrows.

Scuterepenoside A_2 (**14**) showed IR absorption bands at 3440 (OH), 1716, 1708 (C=O) and 1100—1000 cm^{-1} (C–O). The ^{13}C-NMR spectrum exhibited thirty-six carbon signals including those due to a *cis*-cinnamoyl group, a methoxyl group and a hexose moiety, suggesting that **14** was a diterpene glycoside. On acid-hydrolysis, **14** gave glucose and its linking form was deduced to be β from the *J* value (8 Hz) of its anomeric proton signal. The presence of an aldehyde (δ_C 206.1, δ_H 10.29) was also shown by the NMR spectra. The ^{1}H–^{1}H COSY spectrum revealed the ^{1}H–^{1}H spin networks and carbon signals except for a quaternary one were assigned based on ^{1}H–^{13}H COSY spectral data. The connectivities of partial structures deduced from the above data were clarified based on the ^{1}H–^{13}C long-range COSY spectral data (Fig. 7). By considering the chemical shifts of the H-1 (δ 5.50) and H-6 (δ 3.68), the linking position of a *cis*-cinnamoyl group and a glucose moiety was deduced to be C-1 and C-6 oxygen, respectively.

The relative stereochemistry of the decaline moiety was determined from the results of NOE experiments as for **6**. The relative configuration of C-13 and C-16 was assigned as 13*S**, 16*S** from the $J_{H\text{-}13,H\text{-}16}$ value (1.5 Hz).[7]

Enzymatic hydrolysis of **14** gave a genuine aglycone (**14a**), and a 6-*O*-β-glucosyl moiety in **14** was deduced to be in the D form from the difference in molecular optical rotation between **14** and **14a** ($[M]_D$ of **14** $-$ $[M]_D$ of **14a** $= -93.2°$).[8]

The absolute configuration at C-6 was determined to be *S* according to the glycosidation shift rule,[9] based on the fact that the $\Delta\delta$ ($\delta_{glycoside\,(14)} - \delta_{aglycone\,(14a)}$) values of

Table 5. ^{1}H-NMR Spectral Data for **13**, **14**, **14a**, **15** and **16** (Pyridine-d_5)[a]

H No.	13	14	14a	15	16
1	5.62 ddd (11, 11, 4.5)	5.50 ddd (11, 11, 4)	5.61 ddd (11, 11, 4)	5.64 ddd (11, 11, 4.5)	5.52 ddd (11, 11, 4)
2β	1.55 m	1.46 m	ND[b]	1.53 m	1.44 m
2α	2.16 m	2.15 m	ND	2.13 m	2.12 m
3β	1.48 m	1.45 m	ND	1.45 m	1.43 m
3α	1.95 dddd (13, 13, 13, 4.5)	1.93 dddd (13, 13, 13, 4)	1.94 dddd (13, 13, 13, 4)	1.94 m	1.91 m
4	2.36 ddd (12.5, 4.5, 4.5)	2.30 ddd (13, 4.5, 4)	2.25 m	2.29 ddd (12.5, 4.5, 4.5)	2.23 ddd (13, 4.5, 4.5)
6	3.73 dd (11.5, 4)	3.68 m	3.62 m	3.71 dd (11.5, 4)	3.69 dd (11.5, 4)
7β	2.14 m	2.12 m	ND	2.17 m	2.14 m
7α	1.65 m	1.60 m	ND	1.67 m	1.63 m
8	1.64 m	1.59 m	ND	1.77 m	1.74 m
10	1.74 d (11)	1.66 d	ND	1.77 d (11)	1.67 m
11A	1.87 ddd (13, 13, 5)	1.83 ddd (13, 13, 5)	1.84 ddd (13, 13, 5)	1.79 m	1.78 m
11B	1.38 m	1.34 m	ND	1.37 dd (13, 10)	1.34 m
12A	1.74 m	1.54 m	ND	1.87 m	1.71 m
12B	1.48 m	1.54 m	ND	1.69 m	1.55 m
13	2.24 m	2.23 m	ND	2.06 m	2.03 m
14A	2.24 m	2.21 m	ND	2.06 m	2.14 m
14B	1.74 m	1.66 m	ND	1.94 m	1.52 m
15A	4.10 ddd (8, 8, 4)	4.08 ddd (8, 8, 3.5)	4.06 ddd (8, 8, 4)	4.05 ddd (8, 8, 2)	4.04 m
15B	3.95 ddd (8, 8, 7)	3.97 ddd (8, 8, 7)	3.97 ddd (8, 8, 7)	3.84 ddd (8, 8, 7)	3.96 m
16	4.96 d (2)	4.93 d (1)	4.91 d (1.5)	4.94 d (4)	4.97 d (4)
17	0.75 d (6)	0.74 d (6.5)	0.77 d (6)	0.83 d (6.5)	0.81 d (6.5)
18	10.31 d (4.5)	10.29 d (4.5)	10.11 d (5)	10.31 d (4.5)	10.28 d (4.5)
19	1.27 s	1.25 s	1.34 s	1.27 s	1.25 s
20	0.78 s	0.73 s	0.84 s	0.82 s	0.77 s
OMe	3.40 s	3.45 s	3.44 s	3.40 s	3.40 s
Cin-2	6.76 d (16)	6.14 d (13)	6.16 d (13)	6.77 d (16)	6.19 d (13)
Cin-3	7.97 d (16)	7.06 d (13)	7.05 d (13)	7.97 d (16)	7.07 d (13)
Cin-5, 9	7.69 m	7.85 m	7.87 m	7.68 m	7.89 m
Cin-6, 8	7.39 m	7.42 m	7.42 m	7.39 m	7.42 m
Cin-7	7.39 m	7.36 m	7.36 m	7.39 m	7.36 m
Glc-1	4.93 d (8)	4.91 d (8)		4.88 d (8)	4.86 d (8)
Glc-2	3.98 dd (9, 8)	3.96 dd (9, 8)		3.95 dd (9, 8)	3.97 dd (9, 8)
Glc-3	4.26 dd (9, 9)	4.25 dd (9, 9)		4.24 dd (9, 9)	4.23 dd (9, 9)
Glc-4	4.19 m	4.18 dd (9, 9)		4.18 dd (9, 9)	4.17 dd (9, 9)
Glc-5	3.98 m	3.98 ddd (9, 5.5, 2)		3.94 ddd (9, 4, 3.5)	3.93 ddd (9, 5.5, 2)
Glc-6A	4.54 m	4.54 dd (12, 2)		4.53 dd (12, 3.5)	4.53 dd (12, 2)
Glc-6B	4.36 m	4.36 dd (12, 5.5)		4.35 dd (12, 3.5)	4.34 dd (12, 5.5)

a) Coupling constants (J) in Hz are given in parentheses. b) ND: not determined.

the C-5, C-6 and C-7 were −0.6, +10.6 and −3.8 ppm, respectively.

From the above findings, scuterepenoside A_2 (**14**) was concluded to be (4*R*,13*S**,16*S**)-1β-*cis*-cinnamoyloxy-6α-(β-D-glucopyranosyloxy)-16-methoxy-15,16-epoxy-18-neoclerodanal.

Scuterepenoside A_1 (**13**) was deduced to be the *trans*-cinnamoyl form of **14** as determined from comparisons of NMR spectra with those of **14** (Tables 5 and 6).

In its NMR spectra, scuterepenoside A_3 (**15**) had almost the same signal pattern as **14** except for a tetrahydrofuran moiety (Tables 5 and 6). The 13*S**, 16*R** configuration was deduced from the $J_{H\text{-}13,H\text{-}16}$ value (4 Hz),[7] and chemical shift of C-16. Therefore, **15** is the (13*S**,16*R**)-isomer of **13**.

Scuterepenoside A_4 (**16**) was concluded to be the *cis*-cinnamoyl form of **15** by comparison of the NMR spectra with those of **13**, **14** and **15** (Tables 5 and 6).

Scuterepenin H (**17**) was obtained as colorless needles and had absorption bands at 3540 (OH), 1772 (γ-lactone) and 1686 cm^{-1} (conjugated C=O). The UV spectrum had an absorption maximum at 236 nm ($\log\varepsilon = 3.85$). The molecular formula was determined as $C_{20}H_{30}O_4$ from the EI-MS and ^{13}C-NMR spectral data. The ^{1}H- and ^{13}C-NMR spectra indicated the presence of an isopropyl and three *tert*-methyl groups (Tables 7 and 8). The presence of an α,β-unsaturated carbonyl group was suggested from the IR, UV and ^{13}C-NMR spectral data (δ 199.9, 164.6 and 131.8).

The ^{1}H–^{1}H spin networks were clarified from the ^{1}H–^{1}H-COSY spectrum and the assignement of each carbon, except for a quaternary one, was based on the ^{1}H–^{13}C COSY spectral data. The connectivity of each partial structure and the γ-lactone ring was obtained from the ^{1}H–^{13}C long-range COSY spectral data as shown in Fig. 8.

From these data, **17** was deduced to be a 9,11-seco-abietan type diterpenoid.

The relative stereochemistry of the decaline moiety was easily determined as A/B *trans* from the NOEs observed between the H_3-19 and H_3-20, and between the H_3-18 and H-5. However, an assessment of the DIFNOE spectral data to determine the relative stereochemistry of the γ-lactone moiety was unsuccessful because of conformational changes in the γ-lactone moiety and the isopropyl

Table 6. ^{13}C-NMR Spectal Data for **13**—**16** and **14a** (Pyridine-d_5)

C No.	13	14	14a	15	16
1	71.5	71.5	71.9	71.4	71.5
2	32.8	32.5	32.7	32.6	32.4
3	22.1	22.1	22.2	22.0	22.0
4	60.6	60.5	61.8	60.5	60.5
5	46.4	46.4	47.0	46.3	46.4
6	87.4	87.3	76.7	87.5	87.5
7	33.1	33.1	36.9	33.3	33.2
8	35.2	35.2	35.4	35.2	35.1
9	38.9	38.8	38.7	39.1	39.0
10	50.8	50.6	50.8	50.6	50.6
11	38.7	38.8	38.8	39.1	39.0
12	27.4	27.3	27.2	23.3	23.4
13	46.8	46.7	46.7	45.6	45.3
14	31.7	31.6	31.6	30.3	30.3
15	66.9	66.9	66.9	66.8	66.8
16	110.2	110.3	110.3	104.9	105.0
17	16.0	16.1	16.0	16.1	16.1
18	206.1	206.1	202.6	206.3	206.2
19	11.9	11.8	11.1	12.0	11.9
20	18.7	18.7	18.8	18.8	18.8
Cin-1	166.2	165.7	165.8	166.2	165.7
Cin-2	119.2	120.4	120.5	119.4	120.5
Cin-3	145.3	143.2	143.0	145.1	143.2
Cin-4	134.8	135.3	135.3	134.8	135.3
Cin-5, 9	128.6	130.6	130.6	128.5	130.6
Cin-6, 8	129.4	128.6	128.6	129.4	128.6
Cin-7	130.9	129.8	129.7	130.9	129.7
Glc-1	103.6	103.6		103.6	103.6
Glc-2	75.5	75.4		75.4	75.4
Glc-3	78.8	78.8		78.7	78.7
Glc-4	71.4	71.4		71.4	71.4
Glc-5	78.8	78.8		78.7	78.7
Glc-6	62.8	62.8		62.8	62.8

group. Thus, **17** was converted into a trimethylsilylether derivative (**17a**), and detailed NOE experiments were carried out. As a result, NOEs were observed, as depicted with dashed arrows in Fig. 9, demonstrating the relative stereochemistry of 10*R**, 13*S** and 14*S**.

Compound **17** was submitted to $NaBH_4$ reduction to give **17b** as a major product. Compound **17b** proved to be the 7α-ol form from the H-7 signal pattern ($J_{H\text{-}7,H\text{-}6\beta}$ = 4.5 Hz, $J_{H\text{-}7,H\text{-}6\alpha}$ = 2.5 Hz). It afforded a 7α-*O*-benzoate (**17c**) by benzoylation. The CD spectrum of **17c** showed a positive first Cotton effect at 228 nm ($\Delta\varepsilon = +27.1$), denoting that the absolute configuration at C-7 should be *R* according to the exiton chirality rule for an allylic benzoate.[5, 10]

On the basis of all the above findings, the structure of scuterepenin H (**17**) was concluded to be (5*S*,10*R*,13*S*,14*S*)-13-hydroxy-7-oxo-9,11-seco-8-abieten-14,11-olide.

As decribed above, the diterpenoid constituents from the leaves of *Scutellaria repens* were examined and sixteen new neoclerodane-type diterpenes, named scuterepenins A_1 (**1**), A_2 (**2**), B (**3**), C_1 (**4**), C_2 (**5**), D_1 (**6**), D_2 (**7**), E (**8**), F_1 (**9**), F_2 (**10**), G_1 (**11**) and G_2 (**12**), and scuterepenosides A_1 (**13**), A_2 (**14**), A_3 (**15**) and A_4 (**16**), in addition to a new 9,11-secoabietane-type diterpene named scuterepenin H (**17**), have been isolated and characterized.

From a chemotaxonomic point of view, it is a characteristic of *Scutellaria repens* that the C-1 position in all neoclerodane diterpenoids is oxygenated, and the 1,16-epoxy-type of neoclerodane diterpenes, such as scuterepenins G_1 (**11**) and G_2 (**12**), is unique.

Although the absolute configuration of the hydrofurofuran moieties of **6**, **7**, **8**, **9** and **10** has not been

Table 7. ^{1}H-NMR Spectral Data for **17** and Its Derivatives[a]

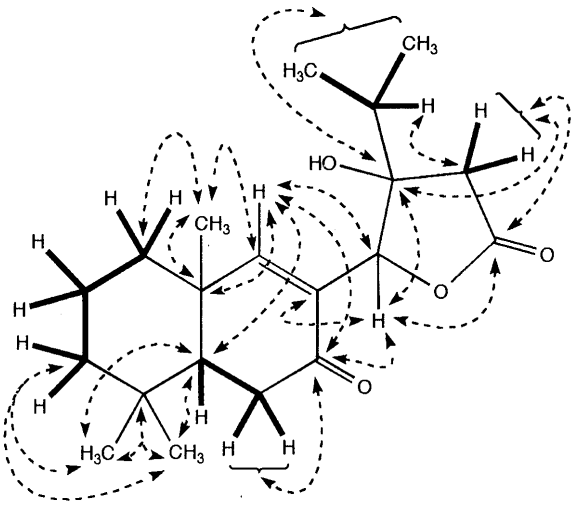
H No.	17[b]	17[c]	17a[b]	17b[c]	17c[c,d]
1β	1.50 m	1.70 br d (13)	1.53 m	1.53 m	1.51 m
1α	1.21 m	1.28 ddd (13, 13, 4)	1.24 ddd (13, 13, 3.5)	1.17 m	1.38 m
2β	1.55 m	1.75 dddd (13, 13, 13, 3,5, 3,5)	1.62 m	1.70 m	1.71 m
2α	1.37 m	1.59 m	1.38 m	1.54 m	1.51 m
3β	1.29 m	1.53 m	1.30 dddd (13, 3.5, 3,5, 2)	1.49 m	1.49 m
3α	1.04 m	1.24 ddd (13, 13, 4)	1.05 ddd (13.5, 13.5, 4)	1.26 ddd (14, 4.5, 4.5)	1.27 ddd (13.5, 13.5, 4.5)
5	1.61 dd (12.5, 5.5)	1.67 dd (14.5, 3.5)	1.59 dd (13, 5.5)	1.44 dd (13, 2.5)	1.63 dd (14.5, 2)
6β	2.49 dd (17.5, 12.5)	2.46 dd (17.5, 14.5)	2.46 dd (17.5, 13)	1.84 ddd (14.5, 13, 4.5)	1.80 ddd (14.5, 13, 4)
6α	2.51 dd (17.5, 5.5)	2.57 dd (17.5, 3.5)	2.48 dd (17.5, 5.5)	1.76 ddd (14.5, 2.5, 2.5)	1.94 ddd (14.5, 2, 2)
7	—	—	—	4.22 m ($W_{h/2}$ = 7)	5.67 dd (4, 2)
9	6.87 s	6.93 d (2)	6.89 s	5.88 d (2)	5.97 br s
12β	3.60 d (17)	2.84 d (18)	3.55 d (18)	2.75 d (17.5)	2.76 d (18)
12α	2.90 d (17)	2.68 d (18)	2.73 d (18)	2.60 d (17.5)	2.44 d (18)
14	5.46 s	5.10 d (2)	5.20 s	4.74 br s	4.75 s
15	1.79 septet (7)	1.53 septet (7)	1.64 septet (6.5)	2.00 septet (7)	1.97 septet (7)
16	1.09 d (7)	0.74 d (7)	0.90 d (6.5)	0.85 d (7)	0.91 d (7)
17	1.07 d (7)	0.95 d (7)	0.91 d (6.5)	0.96 d (7)	0.98 d (7)
18	0.72 s	0.93 s	0.72 s	0.94 s	0.79 s
19	0.79 s	0.94 s	0.79 s	0.87 s	0.84 s
20	1.01 s	1.14 s	1.01 s	0.95 s	1.00 s
OH	7.05 s	4.52 br s	—	3.49 d (5) (7-OH) 3.98 s (13-OH)	Not observed
TMS	—	—	0.27 s	—	—

a) Coupling constants (*J*) in Hz are given in parentheses. *b*) Measured in pyridine-d_5. *c*) Measured in $CDCl_3$. *d*) Benzoyl part: 8.01 m (H-3, 7), 7.43 m (H-4, 6), 7.55 m (H-5).

Table 8. ^{13}C-NMR Spectral Data for **17** and Its Derivatives

C No.	**17**[a]	**17**[b]	**17a**[a]	**17b**[b]	**17c**[b,c]
1	37.8	37.8	37.8	38.7[d]	38.3
2	18.6	18.4	18.7	18.7	18.7
3	41.0	41.0	41.1	41.8	41.7
4	32.9	32.9	32.9	32.6	32.5
5	49.7	50.3	49.7	46.0	45.9
6	36.5	35.7	36.5	29.6	26.7
7	199.8	202.9	199.6	68.0	68.9
8	131.8	129.9	131.5	125.9	125.3
9	164.6	161.2	165.3	143.8	150.8
10	37.3	37.4	37.4	36.3	36.6
11	177.0	174.4	176.3	174.6	174.0
12	43.3	38.5	43.2	38.5[d]	41.1
13	81.5	79.4	85.9	79.9	81.5
14	91.8	86.1	92.2	91.4	93.2
15	33.1	33.4	33.9	32.8	32.0
16	17.2	16.9[d]	17.2[d]	16.7	16.2
17	18.2	17.0[d]	17.9[d]	17.1	17.5
18	31.9	32.2	31.9	32.6	32.5
19	20.8	20.9	20.8	21.3	21.2
20	17.9	17.7[d]	18.3[d]	18.7	18.9
TMS			2.0		

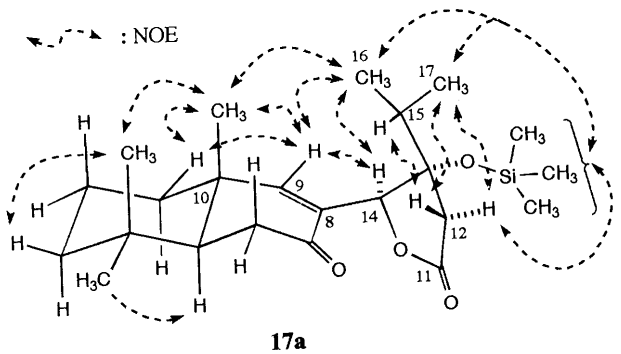
a) Measured in pyridine-d_5. *b*) Measured in $CDCl_3$. *c*) Benzoyl part: 166.1 (C-1), 130.1 (C-2), 129.7 (C-3, 7), 128.5 (C-4, 6), 133.2 (C-5). *d*) May be interchanged in each column.



17

Fig. 8. Gross Planar Structure of **17**

Partial structures deduced from ^{1}H–^{1}H-COSY are depicted with bold lines. ^{1}H–^{13}C long-range correlations observed in ^{1}H–^{13}C long-range COSY are shown by dotted curved arrows.



17a

Fig. 9

confirmed, it is probably the same as **1** from a biogenetic point of view.

Experimental

General Procedures Unless otherwise stated, the following instruments and conditions were employed. Optical rotation was recorded in MeOH on a JASCO DIP-370 digital polarimeter. IR spectra were recorded in KBr disks on a Hitachi 270-30 infrared spectrophotometer and the data are given in cm^{-1}. UV spectra were recorded in MeOH on a Shimadzu UV-3000 recording spectrophotometer and peaks are given in λ_{max} nm ($\log\varepsilon$). NMR spectra were recorded in pyridine-d_5 on a JEOL GSX-400 spectrometer (^{1}H-NMR at 400 MHz, ^{13}C-NMR at 100 MHz) using the residual signal (β-CH) of the solvent as an internal standard (δ_C 123.5, δ_H 7.20), and chemical shifts are given in δ (ppm). When $CDCl_3$ was employed, tetramethylsilane was used as an internal standard. EI-MS and FAB-MS (positive ion mode; matrix, magic bullet) spectra were recorded on a JEOL JMS-DX-300 or a JMS-SX-102A mass spectrometer and major peaks are indicated as *m/z*. CD spectra were recorded in MeOH on a JASCO J-20A or J-720 CD dispersion spectrometer. For TLC, pre-coated plates of silica-gel $60F_{254}$ and RP-$18F_{254s}$ (Merck) were used and spots were detected under UV light (254 nm) and by spraying with dil. H_2SO_4 followed by heating. For column chromatography, Wako-gel C-200 (100—200 mesh, Wako Pure Chemical Indus.) and octadecylsilyl silica-gel (ODS) (Nacalai Tesque, Tokyo Kasei, Merck) were used. HPLC was performed on a Shimadzu LC-6AD pump system with a Shimadzu SPD-6AV UV detector. Preparative HPLC was performed on a YMC-Packed column, D-ODS-5 (20 i.d. × 250 mm) (column A) and a YMC-Packed column D-SIL-5 (20 i.d. × 250 mm) (column B).

Extraction and Separation The plant material of *Scutellaria repens* was collected in Central Nepal in September, 1989 and a voucher specimen is deposited at the Herbarium of the Faculty of Pharmaceutical Sciences, Hokuriku University, Kanazawa, Japan. The dried leaves (1 kg) were extracted with hot MeOH. The MeOH extract was concentrated under reduced pressure and a residue (80 g) was partitioned between water and ether. The ethereal extract (45 g) was chromatographed on Toyopearl HW40 (Tosoh Co., 4 l) and eluted with MeOH–H_2O (MeOH, 30→50→75→100%) to give fr.1—7, in order of elution.

Fraction 5 (4.8 g) was submitted to silica-gel (500 g) column chromatography and eluted with $CHCl_3$–MeOH containing a trace of water (MeOH, 0→15%) to give fr. 1′—8′. Fraction 3′ (1.1 g) was chromatographed on an ODS (100 g) column (solv., 60→70% MeOH) to give a mixture of **6**, **7** and **17**. The mixture was subjected to preparative HPLC (column A; solv., hexane : AcOEt = 6 : 4) to give **17** (20 mg), **6** (130 mg) and **7** (40 mg). Fraction 4′ (426 mg) was chromatographed on an ODS (50 g) column (solv., 60→66% MeOH) and then purified by HPLC (column A; solv., 60% MeOH) to give **8** (15 mg), **9** (9 mg) and **10** (8 mg). Fraction 5′ (968 mg) was chromatographed on an ODS (100 g) column (solv., 60→66% MeOH) and then purified by HPLC (column A; solv., 55% MeOH) to give **11** (20 mg) and **12** (10 mg). Fraction 6′ (260 mg) was chromatographed on an ODS (30 g) column (solv., 60→66% MeOH) and then purified by HPLC (column A; solv., 55% MeOH) to give **4** (25 mg) and **5** (10 mg). Fraction 7′ (649 mg) was chromatographed on an ODS (100 g) column (solv., 55→65% MeOH) to give a mixture of **1** and **2** together with a mixture of **13**, **14**, **15** and **16**. Both mixtures were purified by HPLC (column A; solv., 55% MeOH) and the former gave **1** (70 mg) and **2** (15 mg), while the latter **13** (13 mg), **14** (15 mg), **15** (13 mg) and **16** (10 mg). Fraction 8′ (509 mg) was chromatographed on an ODS (50 g) column (solv., 55→65% MeOH) and then purified by HPLC (column A; solv., 50% MeOH) to give **3** (28 mg).

Scuterepenin A_1 (1) [(4*R*,11*S*,13*R*)-7β-*trans*-Cinnamoyloxy-4,6α,13,18-tetrahydroxy-11,16 : 15,16-diepoxy-1-neoclerodanone] White amorphous powder, $[\alpha]_D^{24}$ −85.0° (*c* = 0.32). IR: 3456, 1712, 1638, 1202, 1164, 780. UV: 277 (4.28), 222 (4.05), 216 (4.11). EI-MS: 148, 131, 129. FAB-MS: 531 $[(M+H)^+]$. High resolution (HR) FAB-MS *m/z*: 531.2592 $[(M+H)^+]$(Calcd for $C_{29}H_{39}O_9$: 531.2594). CD ($c = 3.2 \times 10^{-5}$) $\Delta\varepsilon$: −3.0 (299). ^{1}H-NMR: Table 1. ^{13}C-NMR: Table 2.

6,13,18-Tri-*O*-*trans*-cinnamate (1a) of 1 To a solution of **1** (4.9 mg) in CH_2Cl_2 (2 ml) was added successively 4-dimethylaminopyridine (DMAP, 2 mg), triethyl amine (Et_3N, 0.3 ml) and *trans*-cinnamoyl chloride (15 mg) and the mixture was allowed to stand at room temperature for 24 h. After being diluted with water, the reaction mixture was extracted with AcOEt (30 ml). The AcOEt extract was washed twice

with water, dried over anhyd.Na_2SO_4 and evaporated. The residue was purified with HPLC (column B, solv., hexane : AcOEt = 6 : 4) to give **1a** (5.8 mg). Compound **1a**, white amorphous powder, $[\alpha]_D^{21}$ −61.6° (c = 0.38). IR: 1718, 1640, 1312, 1280, 1022, 1170. UV: 276 (4.94), 222 (4.70), 217 (4.76), 206 (4.72). CD ($c = 1.9 \times 10^{-5}$) $\Delta\varepsilon$: −46.9 (290), +55.0 (261). ^{1}H-NMR: Table 1. ^{13}C-NMR: Table 2.

4,18-Epoxide Derivative (1b) of 1 To a solution of **1** (20 mg) in CH_2Cl_2 (2 ml) was added successively DMAP (5 mg), Et_3N (0.2 ml) and *p*-toluenesulfonyl chloride (20 mg) and the mixture was allowed to stand at room temperature for 24 h. The reaction mixture was treated in the same way as for **1a** and the crude product was purified on a silica-gel (2 g) column (solv., $CHCl_3$: MeOH = 19 : 1) to give **1b** (18 mg). Compound **1b**, white amorphous powder, $[\alpha]_D^{25}$ −63.3° (c = 0.12). IR: 3460, 1718, 1638, 1178, 1020. UV: 277 (4.32), 222 (4.18), 217 (4.23), 205 (4.18). CD ($c = 2.4 \times 10^{-5}$) $\Delta\varepsilon$: −3.2 (300). ^{1}H-NMR: Table 1. ^{13}C-NMR: Table 2.

13-*O*-(*S*)- and 13-*O*-(*R*)-MTPA ester (1c and 1d, respectively) of 1b To a solution of **1b** (5 mg) in CH_2Cl_2 (1 ml) was added successively DMAP (1 mg), Et_3N (0.2 ml) and (+)-MTPA chloride (7 mg) and the mixture was allowed to stand at room temperature for 24 h. The reaction mixture was treated in the same way as for **1a** and the crude product was purified on a silica-gel (2 g) column (solv., benzene : AcOEt = 4 : 1) to give **1c** (4.4 mg). In the same manner as for **1c**, **1d** (3.5 mg) was obtained from **1b** (4 mg). ^{1}H-NMR: Table 1. ^{13}C-NMR: Table 2.

Scuterepenin A_2 (2) [(4*R*,11*S*,13*R*)-7*β*-*cis*-Cinnamoyloxy-4,6α,13,18-tetrahydroxy-11,16 : 15,16-diepoxy-1-neoclerodanone] White amorphous powder, $[\alpha]_D^{27}$ −47.9° (c = 0.16). IR: 3424, 1726, 1628, 1156, 1008, 692. UV: 273 (3.91), 215 (3.93), 206 (4.02). EI-MS: 530 (M^+), 148, 131, 129. HR-EI-MS m/z: 530.2512 (M^+) (Calcd for $C_{29}H_{38}O_9$: 530.2516). CD ($c = 5.5 \times 10^{-5}$) $\Delta\varepsilon$: −2.1 (299). ^{1}H-NMR: Table 3. ^{13}C-NMR: Table 4.

Scuterepenin B (3) [(4*R*,11*S*,13*R*)-7*β*-*trans*-Cinnamoyloxy-2α,4,6α,13,18-pentahydroxy-11,16 : 15,16-diepoxy-1-neoclerodanone] White amorphous powder, $[\alpha]_D^{25}$ −39.8° (c = 0.96). IR: 3432, 1718, 1638, 1282, 924, 749. UV: 277 (4.35), 222 (4.13), 217 (4.20), 205 (4.13). EI-MS: 148, 131, 129. FAB-MS: 547 [(M+H)$^+$]. HR-FAB-MS m/z: 547.2545 [(M+H)$^+$] (Calcd for $C_{29}H_{39}O_{10}$: 547.2543). CD ($c = 3.8 \times 10^{-5}$) $\Delta\varepsilon$: −2.8 (295). ^{1}H-NMR: Table 1. ^{13}C-NMR: Table 2.

Scuterepenin C_1 (4) [(4*R*,11*S*,13*R*)-6α-*trans*-Cinnamoyloxy-7*β*,13-dihydroxy-4,18 : 11,16:15,16-triepoxy-1-neoclerodanone] White amorphous powder, $[\alpha]_D^{23}$ −118.7° (c = 0.80). IR: 3452, 1714, 1640, 1282, 1204, 1182, 1024, 768. UV: 276 (4.20), 223 (3.97), 216 (4.04), 205 (3.99). EI-MS: 512 (M^+), 494, 148, 131, 129. FAB-MS: 513 [(M+H)$^+$]. HR-FAB-MS m/z: 513.2487 [(M+H)$^+$] (Calcd for $C_{29}H_{37}O_8$: 513.2488). CD ($c = 3.9 \times 10^{-5}$) $\Delta\varepsilon$: −2.7 (297). ^{1}H-NMR: Table 1. ^{13}C-NMR: Table 2.

7,13-Di-*O*-*p*-bromobenzoate (4a) of 4 To a solution of **4** (3.7 mg) in CH_2Cl_2 (1 ml) was added successively DMAP (1 mg), Et_3N (0.2 ml) and *p*-bromobenzoyl chloride (6 mg) and the mixture was allowed to stand at room temperature for 24 h. The reaction mixture was processed in the same way as for **1a** and the crude product was purified on a silica-gel (2 g) column (solv., benzene : AcOEt = 4 : 1) to give **4a** (4.3 mg). Compound **4a**, white amorphous powder, $[\alpha]_D^{25}$ −118.9° (c = 0.28). UV: 275 (4.27), 247 (4.57), 223 (4.27), 205 (4.55). FAB-MS: 879 [(M+H)$^+$]. CD ($c = 3.0 \times 10^{-5}$) $\Delta\varepsilon$: −23.5 (272), +26.2 (245). ^{13}C-NMR: ^{1}H-NMR: Table 1. ^{13}C-NMR: Table 2.

Scuterepenin C_2 (5) [(4*R*,11*S*,13*R*)-6α-*cis*-Cinnamoyloxy-7*β*,13-dihydroxy-4,18 : 11,16:15,16-triepoxy-1-neoclerodanone] White amorphous powder, $[\alpha]_D^{24}$ −61.7° (c = 0.39). IR: 3484, 1718, 1636, 1262, 1188, 1060, 1022, 767. UV: 272 (4.01), 215 (4.01), 207 (4.05). EI-MS: 512 (M^+), 494, 148, 131, 129. FAB-MS: 513 [(M+H)$^+$]. HR-FAB-MS m/z: 513.2491 [(M+H)$^+$] (Calcd for $C_{29}H_{37}O_8$: 513.2488). CD ($c = 3.9 \times 10^{-5}$) $\Delta\varepsilon$: −2.7 (297). ^{1}H-NMR: Table 1. ^{13}C-NMR: Table 2.

Scuterepenin D_1 (6) [(4*R*,11*S,13*R**)-6α-*trans*-Cinnamoyloxy-1*β*,7*β*-diacetoxy-11,16 : 15,16-diepoxy-18-neoclerodanal]** White amorphous powder, $[\alpha]_D^{25}$ −45.9° (c = 0.43). IR: 2956, 1742, 1638, 1368, 1234, 1162, 1022. UV: 281 (4.30), 222 (4.04), 217 (4.10). EI-MS: 582 (M^+), 148. FAB-MS: 583 [(M+H)$^+$]. HR-FAB-MS m/z: 583.2904 [(M+H)$^+$] (Calcd for $C_{33}H_{43}O_9$: 583.2907). ^{1}H-NMR: Tables 1 and 3. ^{13}C-NMR: Tables 2 and 4.

Scuterepenin D_2 (7) [(4*R*,11*S*,13*R*)-1*β*-Acetoxy-6α-*trans*-cinnamoyloxy-6α-hydroxy-11,16 : 15,16-diepoxy-18-neoclerodanal] White amorphous powder, $[\alpha]_D^{25}$ −68.4° (c = 0.91). IR: 2948, 1742, 1234, 1160, 1124, 1022. UV: 277 (4.10), 216 (4.04), 205 (4.14). EI-MS: 582 (M^+), 148. FAB-MS: 583 [(M+H)$^+$]. HR-FAB-MS m/z: 583.2909 [(M+H)$^+$] (Calcd for $C_{33}H_{43}O_9$: 583.2907). ^{1}H-NMR: Table 1. ^{13}C-NMR: Table 2.

Scuterepenin E (8) [(4*R*,11*S*,13*R*)-1*β*-Acetoxy-7*β*-*trans*-cinnamoyloxy-6α-hydroxy-11,16 : 15,16-diepoxy-18-neoclerodanal] White amorphous powder, $[\alpha]_D^{25}$ −61.4° (c = 0.30). IR: 3464, 1732, 1716, 1638, 1244, 1170, 1060. UV: 277 (4.31), 222 (4.12), 217 (4.18), 206 (4.13). FAB-MS: 541 [(M+H)$^+$]. HR-FAB-MS m/z: 541.2801 [(M+H)$^+$] (Calcd for $C_{31}H_{41}O_8$: 541.2802). ^{1}H-NMR: Table 3. ^{13}C-NMR: Table 4.

***trans*-Cinnamoylation of 8** To a solution of **8** (3 mg) in CH_2Cl_2 (2 ml) was added successively DMAP (1 mg), triethyl amine (Et_3N, 0.3 ml) and *trans*-cinnamoyl chloride (3 mg) and the mixture was allowed to stand at room temperature for 24 h. The reaction mixture was processed in the same way as for **1a** and the crude product was purified on a silica-gel (2 g) column (solv., benzene : AcOEt = 4 : 1) to give **8a** (2.4 mg). Compound **8a**, white amorphous powder. UV: 276 (4.92), 216 (4.78), 206 (4.82). CD ($c = 1.3 \times 10^{-5}$) $\Delta\varepsilon$: +14.9 (290), −13.1 (262). ^{1}H-NMR: Table 1. ^{13}C-NMR: Table 2.

Scuterepenin F_1 (9) [(4*R*,11*S*,13*R*)-1*β*-*O*-Acetyl-7*β*-*O*-*trans*-cinnamoyl-18*β*-*O*-methyl-6α,18 : 11,16:15,16-triepoxyneoclerodane-1,7,18-triol] White amorphous powder, $[\alpha]_D^{27}$ −78.5° (c = 0.40). IR: 2952, 1734, 1640, 1242, 1170, 1000. UV: 277 (4.31), 221 (4.10), 216 (4.17), 205 (4.11). EI-MS: 148. FAB-MS: 555 [(M+H)$^+$]. HR-FAB-MS m/z: 555.2955 [(M+H)$^+$] (Calcd for $C_{32}H_{43}O_8$: 555.2959). ^{1}H-NMR: Table 3. ^{13}C-NMR: Table 4.

Conversion of 8 into 9 A solution of **8** (2 mg) in 0.1 N HCl–MeOH (0.5 ml) was allowed to stand for 2 h at room temperature. The solution was poured into water (30 ml) and extracted with AcOEt (30 ml). After being washed with water, the AcOEt extract was dried over anhyd. Na_2SO_4 and evaporated. The residue was examined by TLC (solv., benzene : AcOEt = 7 : 3) and HPLC [column, YMC-Packed column, R-ODS-5 (4.6 i.d. × 250 mm); solv., 70% MeOH]. The *Rf* value (0.55) and retention time (28.8 m) of the main product coincided with those of **9**.

Scuterepenin F_2 (10) [(4*R*,11*S*,13*R*)-1*β*-*O*-Acetyl-7*β*-*O*-*cis*-cinnamoyl-18*β*-*O*-methyl-6α,18 : 11,16 : 15,16-triepoxyneoclerodane-1,7,18-triol] White amorphous powder, $[\alpha]_D^{25}$ −63.6° (c = 0.28). IR: 2952, 1734, 1639, 1241, 1170, 1008. UV: 272 (4.02), 214 (4.03), 206 (4.12). EI-MS: 554 (M^+), 148. FAB-MS: 555 [(M+H)$^+$]. HR-FAB-MS m/z: 555.2955 [(M+H)$^+$] (Calcd for $C_{32}H_{43}O_8$: 555.2959). ^{1}H-NMR: Table 3. ^{13}C-NMR: Table 4.

Scuterepenin G_1 (11) [(4*R*,7*R*,11*S*,13*R*)-6α-*O*-*trans*-Cinnamoyl-1,16 : 4,18:11,16-triepoxyneoclerodane-6,7,15-triol] White amorphous powder, $[\alpha]_D^{26}$ −5.7° (c = 0.17). IR: 3464, 2948, 1712, 1642, 1204, 1184, 1118, 1064. UV: 275 (4.32), 222 (4.08), 216 (4.16), 210 (4.09), 205 (4.10). FAB-MS: 499 [(M+H)$^+$]. HR-FAB-MS m/z: 499.2699 [(M+H)$^+$] (Calcd for $C_{29}H_{39}O_7$: 499.2696). ^{1}H-NMR: Table 1. ^{13}C-NMR: Table 2.

Acetate (11a) of 11 A solution of **11** (9 mg) in a mixture of pyridine (0.8 ml) and acetic anhydride (0.8 ml) was allowed to stand at room temperature for 12 h. To the reaction mixture was added successively a small amount of MeOH and water and then it was evaporated. The residue was passed through a silica-gel (2 g) column (solv., benzene : AcOEt = 1 : 1) to give **11a** (7 mg). Compound **11a**, white amorphous powder, $[\alpha]_D^{25}$ −2.0° (c = 0.25). IR: 1746, 1716, 1366, 1312, 1236, 1174, 1118, 1030. UV: 277 (4.38), 222 (4.14), 217 (4.20), 206 (4.13). EI-MS: 582 (M^+), 148 ($C_9H_8O_2$). FAB-MS: 583 [(M+H)$^+$], 605 [(M+Na)$^+$]. ^{1}H-NMR: Table 1. ^{13}C-NMR: Table 2.

7,15-Di-*O*-*p*-bromobenzoate (11b) of 11 To a solution of **11** (3 mg) in CH_2Cl_2 (1 ml) was added successively DMAP (1 mg), Et_3N (0.2 ml) and *p*-bromobenzoyl chloride (7 mg) and the mixture was allowed to stand at room temperature for 24 h. The reaction mixture was processed in the same way as for **1a** and the crude product was purified by HPLC (column B, solv., hexane : AcOEt = 1 : 1) to give **11b** (1 mg). Compound **11b**, white amorphous powder. UV: 275 (4.35), 246 (4.62), 223 (4.35), 216 (4.35), 206 (4.61). FAB-MS: 865 [(M+H)$^+$]. CD ($c = 5.4 \times 10^{-5}$) $\Delta\varepsilon$: −27.2 (269), +25.7 (243). ^{1}H-NMR: 0.96 (3H, d, J = 6.5 Hz, H_3-17), 1.43 (3H, s, H_3-20), 1.55 (3H, s, H_3-19), 1.90 (1H, d, J = 9 Hz), 2.22 (2H, m, H-2α, H-3β), 2.46 (1H, d, J = 4 Hz, H-18B), 2.52 (1H, br ddd, J = 8, 8, 8 Hz, H-13), 3.60 (1H, m, H-18A), 4.21 (1H, m, H-1α), 4.39 (1H, dd, J = 8, 8 Hz, H-11), 4.46 (2H, m, H_2-16), 5.44 (1H, d, J = 9.5 Hz, H-6), 5.78 (1H, dd, J = 10.5, 9.5 Hz, H-7), 6.66 (1H, d, J = 16 Hz, Cin-H-2), 7.77 (1H, d, J = 16 Hz, Cin-H-3), 7.55 (overlapping, Cin-H-5, 9), 7.35 (3H, m, Cin-H-6, 7, 8); *p*-bromobenzoyl part, 7.56, 7.65 (each 2H, m, H-4, 6. × 2), 8.02, 8.10 (each 2H, m, H-3, 7. × 2).

Scuterepenin G_2 (12) [(4*R*,7*R*,11*S*,13*R*)-6α-*O*-*cis*-Cinnamoyl-1,16 : 4,18 : 11,16-triepoxyneoclerodane-6,7,15-triol] White amorphous pow-

der, $[\alpha]_D^{25}$ −11.6° (c=0.26). IR: 3456, 1718, 1200, 1184, 1118, 1062, 990. UV: 271 (4.13), 216 (4.09), 207 (4.14). FAB-MS: 499 [(M+H)$^+$]. HR-FAB-MS m/z: 499.2694 [(M+H)$^+$] (Calcd for $C_{29}H_{39}O_7$: 499.2696). ^{1}H-NMR: Table 1. ^{13}C-NMR: Table 2.

Scuterepenoside A_1 (13) [(4*R*,13*S,16*S**)-1β-*trans*-Cinnamoyloxy-6α-(β-D-glucopyranosyloxy)-16-methoxy-15,16-epoxy-18-neoclerodanal]** White amorphous powder, $[\alpha]_D^{26}$ −14.3° (c=0.41). IR: 3420, 2968, 2892, 1708, 1640, 1166, 1076. UV: 278 (4.26), 222 (4.06), 216 (4.13), 205 (4.13). FAB-MS: 661 [(M+H)$^+$]. HR-FAB-MS m/z: 661.3584 [(M+H)$^+$] (Calcd for $C_{36}H_{53}O_{11}$: 661.3588). ^{1}H-NMR: Table 5. ^{13}C-NMR: Table 6.

Scuterepenoside A_2 (14) [(4*R*,13*S,16*S**)-1β-*cis*-Cinnamoyloxy-6α-(β-D-glucopyranosyloxy)-16-methoxy-15,16-epoxy-18-neoclerodanal]** White amorphous powder, $[\alpha]_D^{27}$ +21.5° (c=0.32). IR: 3440, 1716, 1708, 1166, 1076. UV: 273 (4.06), 215 (4.05), 205 (4.17). FAB-MS: 661 [(M+H)$^+$]. HR-FAB-MS m/z: 661.3585 [(M+H)$^+$] (Calcd for $C_{36}H_{53}O_{11}$: 661.3588). ^{1}H-NMR: Table 5. ^{13}C-NMR: Table 6.

Acid-hydrolysis of 14 To a solution of **14** (5 mg) in dioxane (0.5 ml) was added 4 N H_2SO_4 (0.5 ml) and the mixture was refluxed for 2 h. After cooling, the reaction mixture was neutralized with saturated $Ba(OH)_2$ aq. and centrifuged. The supernatant was evaporated and the residue was examined by TLC (solv., $CHCl_3$: MeOH : H_2O = 25 : 16 : 4) which revealed the presence of glucose.

Enzymatic Hydrolysis of 14 To a suspension of **14** (3.6 mg) in dil. HCOOH aq. (5 ml, pH 5.0) was added cellulase (Sigma C-2415, 30 mg) and the mixture stirred at 37 °C for 7 d. The reaction mixture was extracted with AcOEt (10 ml × 2). The AcOEt solution was washed with H_2O (20 ml × 2) and evaporated. The residue was chromatographed on silica-gel (2 g) eluting with benzene : AcOEt (3 : 2) to give an aglycone (**14a**). Compound **14a**, white amorphous powder, $[\alpha]_D^{25}$ +47.2° (c= 0.08). UV: 274 (4.12), 214 (4.11), 206 (4.19). EI-MS: 498 (M$^+$). ^{1}H-NMR: Table 5. ^{13}C-NMR: Table 6. $\Delta[M]_D$ ($[M]_D$ of **14** − $[M]_D$ of **14a**) = −93.2°. $[M]_D$ of methyl β-D-glucopyranoside = −66°, $[M]_D$ of methyl β-L-glucopyranoside = +66°.

Scuterepenoside A_3 (15) [(4*R*,13*S,16*R**)-1β-*trans*-Cinnamoyloxy-6α-(β-D-glucopyranosyloxy)-16-methoxy-15,16-epoxy-18-neoclerodanal]** White amorphous powder. IR: 3410, 2970, 1710, 1638, 1165, 1074, 1045. UV: 277 (4.23), 222 (4.10), 216 (4.14), 205 (4.13). FAB-MS: 661 [(M+H)$^+$]. HR-FAB-MS m/z: 661.3587 [(M+H)$^+$] (Calcd for $C_{36}H_{53}O_{11}$: 661.3588). ^{1}H-NMR: Table 5. ^{13}C-NMR: Table 6.

Scuterepenoside A_4 (16) [(4*R*,13*S,16*R**)-1β-*cis*-Cinnamoyloxy-6α-(β-D-glucopyranosyloxy)-16-methoxy-15,16-epoxy-18-neoclerodanal]** White amorphous powder. IR: 3400, 1718, 1705, 1164, 1075. UV: 272 (4.10), 215 (4.13), 204 (4.20). FAB-MS: 661 [(M+H)$^+$]. HR-FAB-MS m/z: 661.3586 [(M+H)$^+$] (Calcd for $C_{36}H_{53}O_{11}$: 661.3588). ^{1}H-NMR: Table 5. ^{13}C-NMR: Table 6.

Scuterepenin H (17) [(5*S*,10*R*,13*S*,14*S*)-13-Hydroxy-7-oxo-9,11-seco-8-abieten-14,11-olide] Colorless needles (from MeOH), mp 172—175°, $[\alpha]_D^{27}$ −46.2° (c=0.85). IR: 3524, 2972, 2948, 1776, 1686, 1378, 1186, 1176, 1000. UV: 236 (3.85), 205 (3.46), 202 (3.32). EI-MS: 334 (M$^+$). HR-EI-MS m/z: 334.2144 [(M+H)$^+$](Calcd for $C_{20}H_{30}O_4$: 334.2145). CD ($c = 4.3 \times 10^{-5}$) $\Delta\varepsilon$: +1.5 (337), −5.9 (236), +1.9 (209). ^{1}H-NMR: Table 7. ^{13}C-NMR: Table 8.

Trimethylsilyl Ether Derivative (17a) of 17 To a solution of **17** (4 mg) in pyridine (0.4 ml) was added hexamethyldisilazane (0.1 ml) and trimethylchlorosilane (0.1 ml). The reaction mixture was left to stand overnight and evapolated. A residue was passed through a silica-gel (2 g) column (solv., hexane : AcOEt = 19 : 1) to give a TMS derivative (**17a**, 3 mg) as a white amorphous powder. EI-MS: 406 (M$^+$), 391, 363, 316, 293, 221, 185, 158, 143, 109, 75, 73. ^{1}H-NMR: Table 7. ^{13}C-NMR: Table 8.

$NaBH_4$ Reduction of 17 To a solution of **17** (6 mg) in MeOH (1.5 ml) was added $NaBH_4$ (2 mg) at room temperature and the reaction mixture was left to stand for 2 h. The reaction mixture was diluted with H_2O (10 ml), neutralized with 0.1 N HCl and extracted with AcOEt (10 ml × 2). The AcOEt extract was evaporated and the residue (4.5 mg) was chromatographed on a silica-gel (8 g) column eluting with a gradient of $CHCl_3$: MeOH (1 : 0 → 9 : 1) to give a crude main product, which was purified on a silica-gel (8 g) column (solv., benzene : AcOEt = 4 : 1) to give **17b** (0.8 mg) as a white amorphous powder. UV: 207 (3.61). EI-MS: 336 (M$^+$), 318, 293, 206, 113. ^{1}H-NMR: Table 7. ^{13}C-NMR: Table 8.

7-*O*-Benzoate (17c) of 17b To a solution of **17b** (0.8 mg) in CH_2Cl_2 (1 ml) was added successively DMAP (0.5 mg), Et_3N (0.1 ml) and benzoyl chloride (0.02 ml) and the mixture was allowed to stand at room temperature for 48 h. The reaction mixture was treated in the same way as for **1a** and the crude product was purified on a silica-gel (2 g) column (solv., benzene : AcOEt = 19 : 1) to give **17c** (0.6 mg) as colorless needles (from MeOH), mp 147—150 °C. UV: 281 (3.06), 273 (3.15), 230 (4.23), 205 (4.07). EI-MS: 422 [(M − H_2O)$^+$], 318, 300, 206, 105. FAB-MS: 463 [(M+Na)$^+$]. CD ($c = 6.8 \times 10^{-5}$) $\Delta\varepsilon$: +27.1 (228), +13.3 (212). ^{1}H-NMR: Table 7. ^{13}C-NMR: Table 8.

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