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Studies on the Constituents of Asclepiadaceae Plants. LVIII.[1] The Structures of Five Glycosides, Cynatratoside-A, -B, -C, -D, and -E, from the Chinese Drug "Pai-Wei," *Cynanchum atratum* BUNGE

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The chemical components of the Chinese crude drug "Pai-Wei," dried root of *Cynanchum atratum* BUNGE (Asclepiadaceae), have been studied. Five new oligoglycosides named cynatratoside-A (**3**), -B (**4**), -C (**6**), -D (**8**), and -E (**9**) were isolated by column chromatography and their structures were determined on the basis of chemical and spectral evidence.

Keywords——*Cynanchum atratum* BUNGE; glaucogenin-C; cynatratoside-A; cynatratoside-B; cynatratoside-C; cynatratoside-D, cynatratoside-E

The Chinese crude drug "Pai-Wei," dried root of *Cynanchum atratum* BUNGE (Asclepiadaceae) has been used as an antifebrile and diuretic in China. On the other hand, "Pai-Ch'ien," dried root of *C. glaucescens* HAND-MAZZ (Asclepiadaceae), which is closely related to *C. atratum*, has been used as an antitussive and expectorant. However, confusion exists not only in the therapy but also in nomenclature between these two drugs[2] in different parts of China. In our recent studies on glycosides of "Pai-Ch'ien," we showed that the aglycones have a novel 13,14 : 14,15-disecopregnane-type skeleton.[3,4] In this paper, we wish to report five new oligoglycosides isolated from "Pai-Wei" with the same skeleton. They were named cynatratoside-A (**3**), -B (**4**), -C (**6**), -D (**8**), and -E (**9**). Glaucogenin-C (**1**), which is known in the form of the thevetoside[3] (**10**) from "Pai-Ch'ien," was first separated as the free compound from the hydrolysate of the crude glycoside fraction. The crude glycoside fraction was separated into benzene-soluble and insoluble fractions. The former fraction gave **4** and **6**, and the latter gave **8** and **9**.

Glaucogenin-C (**1**), needles from acetone, has the molecular formula $C_{21}H_{28}O_5$ on the bases of elemental analysis and the field desorption mass spectrum (FD-MS). Infrared (IR) absorptions at 3600 and 1685 cm^{-1} showed the presence of hydroxyl and ester groups. The proton nuclear magnetic resonance (^{1}H-NMR) spectrum of **1** showed signals due to an angular methyl at δ 0.94 (3H, s) and an olefinic proton at 5.40 (1H, d, J=5.3 Hz), indicating that **1** is a Δ^5-steroid posessing ordinary A and B rings. The presence of an additional trisubstituted double bond was suggested by the deshielded signal at δ 6.26 (1H, d, J=2 Hz). The remaining ^{1}H-NMR signals of **1** were as follows: a tertiary methyl at 1.54 (3H, s), one proton at δ 3.45 (1H, dd, J=8, 2 Hz), one hydroxy-methine proton at δ 3.54 (1H, m), and three protons adjacent to oxygen at 3.85 (1H, dd, J=10, 9 Hz), 4.16 (1H, dd, J=9, 7 Hz) and 5.32 (1H, ddd, J=10, 8, 7 Hz). The IR spectrum of the acetate (**2**) exhibited no hydroxyl absorption and the ^{1}H-NMR spectrum displayed one acetyl signal at δ 2.04 ppm (3H, s) and an acetoxy-methine signal at 4.60 (1H, m). All of these data are consistent with the

13,14 : 14,15-disecopregnane-type skeleton.[3] The carbon-13 nuclear magnetic resonance (^{13}C-NMR) data of **1** were compared with those of glaucogenin-C mono-D-thevetoside (**10**) and it was found that the chemical shifts of **10** are different from those of **1** at C-2 (−1.7 ppm), C-3 (+7 ppm) and C-4 (−4.0 ppm) due to the glycosidation shift.[5] These results indicated that **1** is glaucogenin-C which was isolated from "Pai-Ch'ien" as the mono thevetoside (**10**).

Cynatratoside-A (**3**), colorless needles, has similar spectroscopic features to **1**. FD-MS of **3** gave the molecular ion peak at M^+ m/z 504 and a prominent peak at m/z: 346 (M^+ −(2,6-deoxyhexose)). On hydrolysis, **3** gave oleandrose and **1**. Since glycosidation shifts[5] were observed at C-2 (−2.1 ppm), C-3 (+6.4 ppm), and C-4 (−3.8 ppm) in the ^{13}C-NMR for the aglycone moiety of **3**, the oleandrose is linked with the C-3 hydroxyl group of **1**. Moreover the anomeric proton signal at 4.60 (1H, dd, J=11, 3 Hz) in the ^{1}H-NMR spectrum is consistent with the ^{13}C-NMR chemical shifts for the sugar moiety of methyl β-D-oleandropyranoside (**11**)[6] (Table II), so the β-mode of linkage for oleandrose is established. Therefore the structure of **3** was established as glaucogenin-C 3-*O*-β-D-oleandropyranoside. Since this glycoside was not detected in the crude glycoside fraction, **3** is probably an artefact formed during the acid hydrolysis process.

Cynatratoside-B (**4**), gave **1**, **3**, oleandrose, digitoxose and L-cymarose on acid hydrolysis. The sugar sequence was determined by FD-MS of **4**; the prominent peaks at m/z: 643, 504, and 360, other than molecular ion peak M^+ 778, are attributable to initial loss of the terminal cymarose, followed by digitoxose, and finally the oleandrose linked to the aglycone. The anomeric proton signals at δ 5.00 (1H, dd, J=10, 2 Hz), 4.91 (1H, br d, J=3 Hz) and 4.54 (1H, dd, J=10, 2 Hz) in the ^{1}H-NMR spectrum indicated two β and one α sugar linkages. By the partially relaxed Fourier transform (PRFT) method, a set of signals with longer spin-lattice relaxation times (T_1=0.20 s; 76.6, 72.7, and 67.1) among the signals due to sugar carbons can be assigned to terminal α-L-cymarose, on the basis of comparison with the ^{13}C-NMR chemical shifts of methyl α-L-cymaropyranoside (**12**) and methyl β-D-cymaropyranoside (**13**).[3] In order to determine which hydroxyl group (at C-3 or C-4) of the digitoxose is linked to the terminal cymarose, **4** was acetylated in usual manner to give the diacetate (**5**). By comparison of the 500 MHz ^{1}H-NMR spectrum of **3** with that of **4**, it is found that the signal at δ 4.06 (1H, m) assignable to 3″-CH of digitoxose was shifted to low field at δ 5.31. The coupling pattern of 3′-CH of digitoxose is easily distinguishable from other proton signals due to protons adjacent to oxygen except for 3‴-CH of cymarose at δ 3.63. The signal of 3‴-CH of cymarose is slightly shifted to 3.69 after acetylation (see later in the case of **6**). Another low-field-shifted proton signal at δ 4.60 (1H, dd, J=9.2, 3 Hz) is assignable to 4‴-CH. These results indicate the presence of a 1—4 glycosyl linkage between the terminal cymarose and the digitoxose in **4**. From these results, we concluded that the structure of cynatratoside-B is glaucogenin-C 3-*O*-α-L-cymaropyranosyl-(1→4)-β-D-digitoxopyranoyl-(1→4)-β-D-oleandropyranoside.

Cynantratoside-C (**6**) showed essentially the same fragmentation pattern as **4** in FD-MS. Acidic hydrolysis of **6** gave **1**, **3**, digitoxose and oleandrose. Therefore it was suggested that the difference between **6** and **4** is only in the terminal sugar. To determine whether the terminal oleandrose was linked to the C-3 or C-4 OH group of digitoxose, **6** was acetylated slimilarly to the case of **4**, to give a diacetate (**7**). In the 500 MHz ^{1}H-NMR spectra of **7**, there were two obviously downfield-shifted signals (from δ 3.17 (1H, t, J=9.5 Hz) and 4.11 (1H, m) to 4.63 and 5.28, respectively). The former signal is assignable to 4‴-CH of the terminal oleandrose, and the latter to 3″-CH of digitoxose on the basis of their coupling patterns, indicating the presence of a 1—4 glycosyl linkage between the oleandrose and digitoxose in **6**. The ^{13}C-NMR spectra of **4** and **6** indicated the structures of the sugar chains are the same except for terminal sugars. Since the presence of one anomeric proton signal at δ 4.96 (1H, br d, J=3 Hz) in **7** is very clear, the mode of linkage of terminal oleandrose is α. This is

TABLE I. ^{13}C-NMR Chemical Shifts for the Aglycone Moieties

	1	3	4	6	8	9	10
C-1	36.7	36.6	36.5	36.5	36.5	36.5	36.6
C-2	32.3	30.2	30.1	30.1	30.0	30.0	30.6
C-3	71.1	77.5	77.6	77.6	77.5	77.5	78.1
C-4	43.0	39.2	39.1	39.1	39.0	39.0	39.0
C-5	141.5	140.7	140.6	140.7	140.6	140.6	140.7
C-6	119.7	120.5	120.4	120.4	120.4	120.4	120.4
C-7	30.0	30.0	30.0	30.1	30.1	30.0	30.0
C-8	53.3	53.3	53.3	53.3	53.3	53.2	53.3
C-9	40.7	40.8	40.7	40.7	40.7	40.7	40.7
C-10	38.6	38.7	38.7	38.7	38.6	38.7	38.7
C-11	24.0	24.0	24.0	24.0	23.9	23.9	23.9
C-12	28.4	28.5	28.5	28.5	28.4	28.4	28.4
C-13	118.5	118.5	118.5	118.5	118.5	118.5	118.4
C-14	175.5	175.5	175.4	175.4	175.4	175.4	175.4
C-15	67.8	67.8	67.9	67.8	67.7	67.7	67.7
C-16	75.5	75.6	75.6	75.6	75.5	75.5	75.5
C-17	56.2	56.2	56.2	56.2	56.2	56.2	56.2
C-18	143.8	143.9	143.8	143.8	143.8	143.8	143.8
C-19	18.1	18.0	18.0	18.0	17.9	17.9	18.6
C-20	114.4	114.4	114.4	114.4	114.3	114.3	114.3
C-21	24.8	24.8	24.8	24.8	24.8	24.8	24.8

TABLE II. ^{13}C-NMR Chemical Shifts for the Sugar Moieties

	3	4	8	6	9	11	12	13	14
C-1′	98.3	98.2	98.1	98.1	98.1	101.0			
C-2′	37.5	38.0	37.9	38.0	37.9	36.6			
C-3′	81.7	79.3	79.2	79.2	79.2	81.3			
C-4′	76.4	83.1	83.0	83.2	83.1	76.2			
C-5′	72.9	71.7	71.7	71.7	71.7	72.6			
C-6′	18.8	18.9	18.8	18.8	18.8	18.4			
OMe	57.0	57.4	57.3	57.5	57.4	56.7			
C-1″		98.5	98.4	98.5	98.5				
C-2″		38.5	38.5	38.7	38.7				
C-3″		69.1	69.0	69.5	68.9				
C-4″		80.7	80.9	82.3	82.2				
C-5″		67.9	67.7	67.8	67.7				
C-6″		18.4	18.4	18.4	18.4				
C-1‴		98.3	98.2	100.2	99.7		97.6	99.4	98.7
C-2‴		32.2	31.7	35.8	35.4		31.9	35.1	35.1
C-3‴		76.6	73.5	78.8	75.8		76.5	78.5	79.0
C-4‴		72.7	78.4	76.9	82.2		73.2	74.0	76.6
C-5‴		67.1	65.8	68.9	67.9		65.2	71.0	68.4
C-6‴		18.6	18.6	18.6	18.6		18.9	18.9	18.4
OMe		56.7	57.0	57.0	56.7		56.7	57.8	57.0
C-1⁗			102.2		104.9				
C-2⁗			75.1		75.5				
C-3⁗			78.2		78.2				
C-4⁗			71.7		71.8				
C-5⁗			78.4		78.6				
C-6⁗			62.8		62.3				

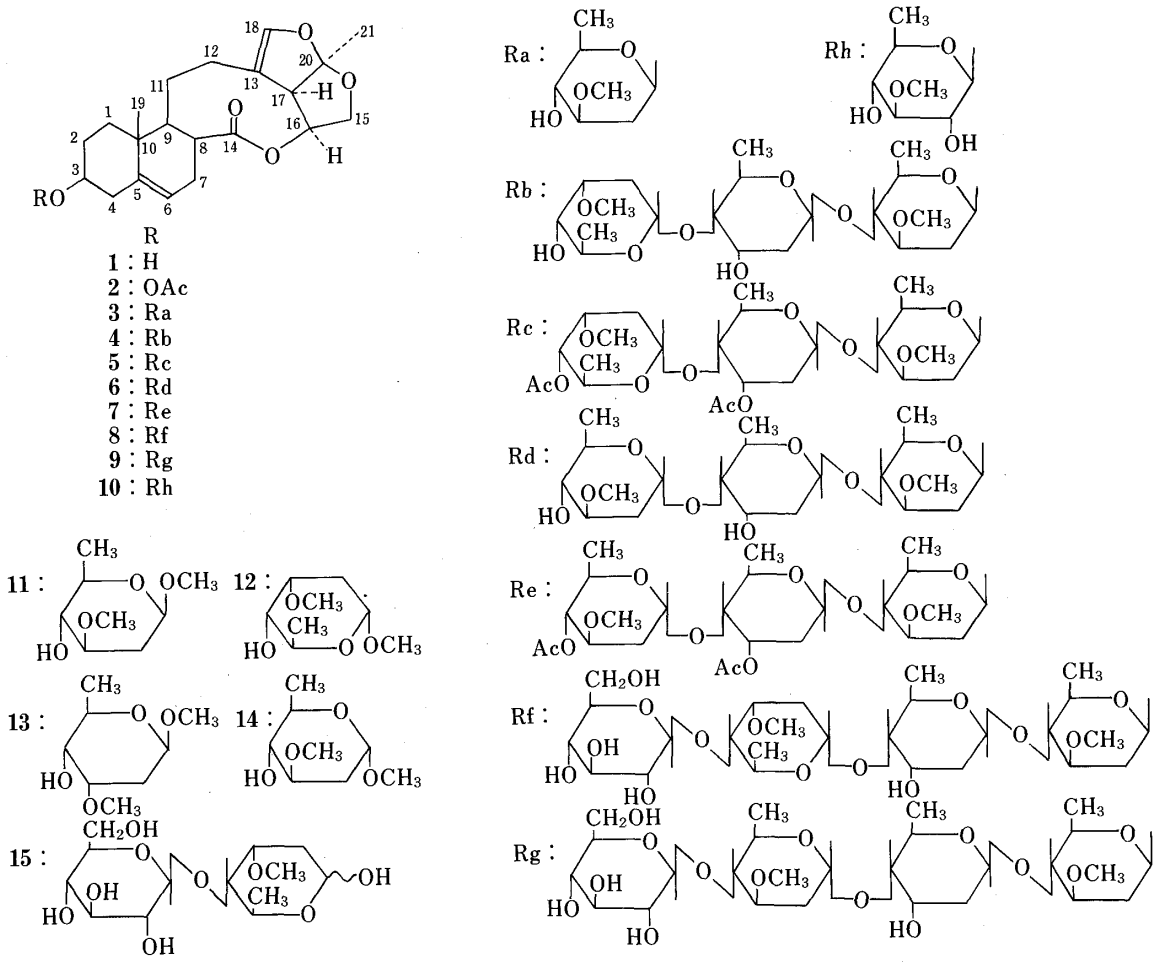

Chart 1

consistent with the assignment of terminal α-D-oleandrose (**14**)[6] by the PRFT method, in which signals with longer spin relaxation times were seen at 68.9, and 78.8 (T_1 = 20 ms). Therefore, the structure of **6** was deduced to be glaucogenin-C 3-*O*-α-D-oleandropyranosyl-(1→4)-β-D-digitoxopyranosyl-(1→4)-α-D-oleandropyranoside.

Cynatratoside-D (**8**), $C_{47}H_{72}O_{19}$, liberated **1**, **3**, digitoxose, oleandrose and glaucobiose (**15**)[8] on mild acidic hydrolysis. These compounds were identified by thin layer chromatographic comparison with authentic samples. This glycoside (**8**) showed four anomeric proton signals at δ 5.08 (1H, dd, J = 9, 2 Hz), 4.99 (1H, br s), 4.56 (1H, dd, J = 8, 3 Hz), and 4.36 (1H, d, J = 6.8 Hz), and four anomeric carbon signals at δ 98.1 98.2, 98.4, and 102.2 in its ^{1}H- and ^{13}C-NMR spectra. The FD-MS of **8** and elemental analysis suggested the molecular formula; there was an ion peak at m/z 963 ($M+Na^+$). Enzymatic hydrolysis of **8** gave cynatratoside-B (**4**) as a deglucosyl derivative, which was identical with an authentic sample in IR, ^{1}H-NMR, ^{13}C-NMR, and $[\alpha]_D$ comparisons. Glucose in the water layer was identified by thin-layer chromatography (TLC) comparison with an authentic sample. Thus, the structure of **8** was established as glaucogenin-C 3-*O*-β-D-glucopyranosyl-(1→4)-α-L-cymaropyranosyl-(1→4)-α-D-digitoxopyranosyl-(1→4)-β-D-oleandropyranoside.

Cynatratoside-E (**9**), showed essentially the same fragmentation pattern as **8** in its FD-MS. A comparison of the ^{13}C-NMR data with those of **8** revealed that a set of signals at 99.7, 35.4, 75.8, 82.2, 67.9, 18.8 and 57.6 which were assignable to carbons of α-oleandropyranoside replaced a set of signals due to cymarose in the case of **8**. Enzymatic hydrolysis of **9** gave cynatratoside-C (**6**) as a deglucosyl derivative which was identical with an authentic sample in

IR, ^{1}H-NMR, ^{13}C-NMR, FD-MS, and $[\alpha]_D$ comparisons and glucose identified by TLC comparison with an authentic sample. Therefore the structure of **9** was established as glaucogenin-C 3-*O*-α-D-glucopyranosyl-(1→4)-β-D-oleandropyranosyl-(1→4)-β-D-digitoxopyranosyl-(1→4)-α-D-oleandropyranoside.

Experimental

Melting points were determined on a Kofler hot stage apparatus and are uncorrected. Optical rotations were measured with a JASCO DIP-4 digital polarimeter at room temperature. IR spectra were recorded on a JASCO A-102 spectrometer. ^{1}H-NMR spectra were run on a JEOL FX-200 (200 MHz) or an FX-500 (500 MHz) spectrometer in $CDCl_3$ solution an ^{13}C-NMR spectra on a JEOL FX-100 (25 MHz) or FX-200 (50 MHz) spectrometer in C_5D_5N soln with tetramethylsilane (TMS) as a standard. Electron impact mass spectrometry (EI-MS) was done with a JEOL JMS-D-300 machine and FD-MS with a JEOL JMS-OISG-2 machine. TLC was performed on Merck precoated plates, Kieselgel 60 F_{254} or RP-18 F_{254}. Column chromatography was carried out on Wakogel C-200 (200 mesh), MCI GEL CHP 20P or RP-8 (Merck).

Extraction from "Pai-Wei"——Commercial "Pai-Wei" from Kunming (15 kg) was powdered. The material (14.5 kg) was extracted with hot MeOH and concentrated to give 1.2 kg of dark-brown tar. This was dissolved in 200 ml of MeOH to give a syrup, and 400 ml of water was added. After extraction with petroleum ether (1500 ml), the water layer was extracted with $CHCl_3$. Evaporation of the $CHCl_3$ gave the crude glycoside fraction (500 g). Then 6 l of benzene was added to 300 g of the crude glycoside fraction and after standing overnight, the benzene–soluble portion (50 g) and the benzene–insoluble portion (249 g) were obtained. Both portions gave positive Liebermann–Burchard and Keller–kiliani reactions.

The crude glycoside fraction (30 g) was dissolved in 240 ml of MeOH and the solution was warmed to 65 °C. Then 60 ml of 0.2 N H_2SO_4 which had been prewarmed to 65 °C was poured into the solution and the mixture was kept at around 74 °C. After 40 min, 240 ml of water was added to the solution and MeOH was evaporated off. Successive extractions with Et_2O and $CHCl_3$ afforded a crude aglycone (18 g), which was subjected to silica gel column chromatography with solvent of increasing polarity from 3% MeOH–$CHCl_3$ to 40% MeOH–$CHCl_3$ to obtain four fractions. Fraction 1 (2 g) mainly containing **1** and **3**, was rechromatographed with hexane–EtOAc (1 : 1) to give **1** (250 mg) as colorless needles from acetone and **3** (80 mg) as colorless fine needles from hexane–EtOAc.

Glaucogenin-C (1)——Colorless needles, mp 205—206 °C, $[\alpha]_D$ +83.2° (c=1.00 MeOH). *Anal.* Calcd for $C_{21}H_{28}O_5$: C, 69.97; H, 7.83. Found: C, 69.73; H, 7.82. IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3600, 1685, 1195. FD-MS m/z: 360 (M^+). ^{1}H-NMR ($CDCl_3$) δ: 0.94 (3H, s, 19-CH_3) 1.54 (3H, s, 21-CH_3), 3.45 (1H, dd, J=8, 2 Hz, 17-CH), 3.54 (1H, m, 3-CH), 3.85 (1H, dd, J=10, 9 Hz, 15-CH_β), 4.16 (1H, dd, J=9, 7 Hz, 15-CH_α), 5.32 (1H, ddd, J=10, 8, 7 Hz, 16-CH), 5.40 (1H, d, J=5.3 Hz, 6-CH), 6.26 (1H, d, J=2 Hz, 18-CH). ^{13}C-NMR: see Table I.

Acetylation of 1——Compound **1** (8 mg) was dissolved in 1 ml of pyridine, then Ac_2O (0.6 ml) was added, and the mixture was allowed to stand at room temperature for 12 h and H_2O (20 ml) was added. The resulting mixture was extracted with Et_2O (60 ml). The ether layer was washed with 2 N HCl (50 ml), sat. $NaHCO_3$ aq. (50 ml) and sat. NaCl aq. (50 ml) successively, then dried over Na_2SO_4, and removal of the solvent gave **2** (6 mg) as colorless needles from hexane–EtOAc, mp 234—236 °C, $[\alpha]_D$ +10.9° (c=0.34, $CDCl_3$). IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 1710, 1160, 1080, 1030. FD-MS m/z: 402 (M^+). ^{1}H-NMR ($CDCl_3$) δ: 0.95 (3H, s, 19-CH_3), 1.54 (3H, s, 21-CH_3), 2.04 (3H, s, –O–$COCH_3$), 3.44 (1H, dd, J=8, 2 Hz, 17-CH), 3.85 (1H, dd, J=10, 9 Hz, 15-CH_α), 4.16 (1H, dd, J=9, 7 Hz, 15-CH_β), 4.60 (1H, m, 3-CH), 5.31 (1H, ddd, J=10, 8, 7 Hz, 16-CH), 5.43 (1H, d J=5.4 Hz, 6-CH), 6.25 (1H, d, J=2 Hz, 16-CH).

Cynatratoside-A (3)——Colorless fine needles, mp 209—210 °C, $[\alpha]_D$ +15.5° (c=1.00, MeOH). *Anal.* Calcd for $C_{28}H_{40}O_8 \cdot 1/2H_2O$: C, 64.35; H, 8.01. Found: C, 64.05; H, 7.67. IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3600, 1700, 1680, 1180, 900. FD-MS m/z: 504 (M^+). ^{1}H-NMR ($CDCl_3$) δ: 0.93 (3H, s, 19-CH_3), 1.34 (3H, d, J=5.8 Hz, 5′-CH_3), 1.54 (3H, s, 21-CH_3), 3.39 (3H, s, 3′-OCH_3), 4.16 (1H, dd, J=9, 7 Hz, 15-CH_α), 4.60 (1H, dd, J=11, 3 Hz, 1′-CH), 5.30 (1H, ddd, J=10, 8, 7 Hz, 16-CH), 5.40 (1H, d, J=5.4 Hz, 6-CH), 6.26 (1H, d, J=2 Hz, 18-CH). ^{13}C-NMR: see Table I and II.

Acidic Hydrolysis of 3——A solution of **3** (40 mg) in 2 ml dioxane was treated with 2 ml of 0.1 N H_2SO_4 and the mixture was kept at 70 °C for 2 h, then neutralized with saturated $Ba(OH)_2$ aq. The precipitate was filtered off. The filtrate was concentrated and chromatographed on a column of silica gel (16 g of Wakogel C-200) with 1% MeOH–$CHCl_3$ to obtain the aglycone (**15**) and oleandrose identified by TLC comparison with an authentic sample.

Compound 15——Colorless needles, mp 205—207 °C, $[\alpha]_D$ +84.8° (c=1.00, MeOH). *Anal.* Calcd for $C_{21}H_{28}O_5$: C, 69.97; H, 7.83. Found: C, 70.00; H, 7.92. IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3600, 1680, 1490, 1390, 1330, 1180, 1000, 900. FD-MS m/z: 360 (M^+). ^{1}H-NMR ($CDCl_3$) δ: 0.94 (3H, s, 19-CH_3), 1.54 (3H, s, 21-CH_3), 3.44 (1H, dd, J=8, 2 Hz, 17-CH), 3.54 (1H, m, 3-CH), 3.85 (1H, dd, J=10, 9 Hz, 15-CH_β),4.16 (1H, dd, J=9, 7 Hz, 15-CH_α), 5.30 (1H, dd, J=10, 8, 7 Hz, 16-CH), 5.40 (1H, d, J=2 Hz, 6-CH), 6.26 (1H, d, J=2 Hz, 18-CH). These data were identical with those of glaucogenin-C (**1**).

Isolation of 4 and 6——The benzene-soluble portion (34 g) of the crude glycoside was applied to a column of silica gel (1.05 kg of Wakogel C-200) and eluted with $CHCl_3$–MeOH (98 : 2) to give five fractions. Fraction 3 (20 g),

containing mainly glycosides, was separated repeatedly on a silica gel (Wakogel C-200) column with $CHCl_3$–MeOH (98 : 2) and petroleum ether–acetone (8 : 2) to give pure **4** (120 mg) and **6** (100 mg).

Cynatratoside-B (4)——An amorphous powder, mp 100—103 °C, $[\alpha]_D$ −21.5° (c=1.00, MeOH). *Anal.* Calcd for $C_{41}H_{62}O_{14}\cdot 1/2H_2O$: C, 62.50; H, 8.06. Found: C, 62.32; H, 7.87. IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3550, 1730, 1655, 1450, 1380, 1305, 1160, 1110, 1080, 1050, 1010, 985. FD-MS m/z: 778 (M^+ base peak), 634 (M^+-144), 504 (634—130), 360 (504—144). ^{1}H-NMR ($CDCl_3$) δ: 0.92 (3H, s, 19-CH_3), 1.25 and 1.30 (6H, br d, d, J=4.9 Hz and 3H, d, J=5.8 Hz, 6′-, 6″-, and 6‴-CH_3), 1.53 (3H, s, 21-CH_3), 3.40 and 3.42 (each 3H, s, 3′- and 3‴-OCH_3), 3.84 (1H, dd, J=10, 9 Hz, 15-CH_β), 4.06 (1H, m, 3″-CH), 4.16 (1H, dd, J=9, 7 Hz, 15-CH_α), 4.54 (1H, dd, J=10, 2 Hz, 1′-CH), 4.91 (1H, br d, J=3 Hz, 1‴-CH), 5.00 (1H, dd, J=10, 2 Hz, 1′-CH), 5.31 (1H, ddd, J=10, 8, 7 Hz, 16-CH), 5.38 (1H, d, J=5 Hz, 6-CH), 6.25 (1H, br s, 18-CH). ^{13}C-NMR: see Tables I and II.

Acetylation of 4——Compound **4** (20 mg) was acetylated at room temperature for 36 h, and the diacetate (**5**) (20 mg) was obtained as an amorphous powder, mp 90—94 °C, $[\alpha]_D$ −14° (c=1.00, $CHCl_3$). FD-MS m/z: 863 (M^++H). IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 1720, 1185, 1080, 1045, 915. ^{1}H-NMR ($CDCl_3$) δ: 0.92 (3H, s, 19-CH_3), 1.26 and 1.29 (6H, br d, J=5.8 Hz, and 3H, d, J=7.3 Hz, 6′-, 6″, and 6‴-CH_3), 1.54 (3H, s, 21-CH_3), 2.10 (3H, s, –OCOCH_3), 3.34 and 3.41 (each 3H, s, 3′- and 3‴-OCH_3), 3.85 (1H, dd, J=10, 9 Hz, 15-CH_β), 4.16 (1H, dd, J=9, 7 Hz, 15-CH_α), 4.54 (1H, dd, J=10, 2 Hz, 1′-CH), 4.60 (1H, dd, J=9, 3 Hz, 4‴-CH), 4.83 (1H, br d, J=3 Hz, 1‴-CH), 4.95 (1H, dd, J=10, 2 Hz, 1″-CH), 5.31 (2H, m, 3″ and 16-CH), 5.39 (1H, d, J=5 Hz, 6-CH), 6.25 (1H, br s, 18-CH).

Acidic Hydrolysis of 4——A solution of 80 mg of **4** in 10 ml MeOH was treated with 20 ml 0.05 N H_2SO_4 and the mixture was kept at 60 °C for 1 h, then diluted with water (10 ml) and concentrated to 30 ml. The concentrate was kept at 70 °C for 30 min, then neutralized with sat. $Ba(OH)_2$ aq., and the precipitate was filtered off. The filtrate was concentrated and chromatographed on a column of silica gel (16 g of Wakogel C-200) with 1% MeOH–$CHCl_3$ to obtain **17** (22 mg), **18** (4 mg), digitoxose (identified by TLC comparison with an authentic sample), and cymarose (3 mg) which showed, $[\alpha]_D$ −50° (c=0.3, H_2O) indicating L-cymarose.

Compound 17——Colorless needles, mp 203—205 °C, $[\alpha]_D$ +85.5° (c=1.00, MeOH). *Anal.* Calcd for $C_{21}H_{28}O_5$: C, 69.97; H, 7.83. Found: C, 69.68; H, 7.87. IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3600, 1680, 1490, 1390, 1330, 1180, 1000, 900. FD-MS m/z: 360 (M^+). ^{1}H-NMR ($CDCl_3$) δ: 0.93 (1H, s, 19-CH_3), 1.54 (1H, s, 21-CH_3), 3.44 (1H, dd, J=8, 2 Hz, 17-CH), 3.53 (1H, m, 3-CH), 3.85 (1H, dd, J=10, 9 Hz, 15-CH_β), 4.16 (1H, dd, J=9, 7 Hz, 15-CH_α), 5.31 (1H, ddd, J=10, 8, 7 Hz, 16-CH), 5.40 (1H, d, J=5 Hz, 6-CH), 6.26 (1H, d, J=2 Hz, 18-CH). These data were identical with those of glaucogenin-C (**1**).

Compound 18——Colorless fine needles, mp 205—208 °C, $[\alpha]_D$ +18.5° (c=1.00, MeOH). *Anal.* Calcd for $C_{28}H_{40}O_8\cdot H_2O$: C, 64.35; H, 8.10. Found: C, 64.50; H, 7.75. IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3600, 1680, 1490, 1450, 1390, 1180, 900. FD-MS m/z: 504 (M^+). ^{1}H-NMR ($CDCl_3$) δ: 0.93 (1H, s, 19-CH_3), 1.54 (1H, s, 21-CH_3), 1.34 (3H, d, J=5.54 Hz, 6′-CH_3), 3.39 (3H, s, 3′-OCH_3), 3.85 (1H, dd, J=10, 9 Hz, 15-CH_β), 4.16 (1H, dd, J=9, 7 Hz, 15-CH_α), 4.60 (1H, dd, J=11, 3 Hz, 1′-CH), 5.30 (1H, ddd, J=10, 8, 7 Hz, 16-CH), 5.40 (1H, d, J=5.4 Hz, 6-CH), 6.26 (1H, br s, 18-CH). These data were identical with those of cynatratoside-A (**3**).

Cynatratoside-C (6)——An amorphous powder, mp 104—108 °C, $[\alpha]_D$ −7.2° (c=1.00, MeOH). *Anal.* Calcd for $C_{41}H_{62}O_{14}\cdot 1/2H_2O$: C, 62.50; H, 8.06. Found: 62.39; H, 7.99. IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3600, 1700, 1680, 1490, 1390, 1340, 1280, 1180, 1130, 950, 900. FD-MS m/z: 778 (M^+ base peak), 634 (M^+-144), 504 (634−130), 360 (504−144). ^{1}H-NMR ($CDCl_3$) δ: 0.92 (3H, s, 19-CH_3), 1.26 and 1.29 (6H, br d, J=5.8 Hz and 3H, d, J=5.3 Hz, 6′-, 6″-, and 6‴-CH_3), 1.54 (3H, s, 21-CH_3), 3.41 (6H, s, 3′- and 3″-OCH_3), 3.84 (1H, dd, J=10, 9 Hz, 15-CH_β), 4.11 (1H, m, 3″-CH), 4.16 (1H, dd, J=9, 7 Hz, 15-CH_α), 4.54 (1H, dd, J=10, 2 Hz, 1′-CH), 5.03 (2H, br d, J=4.4 Hz, 1″- and 1‴-CH), 5.32 (1H, ddd, J=10, 8, 7 Hz, 16-CH), 5.39 (1H, d, J=5 Hz, 6-CH), 6.26 (1H, br s, 18-CH). ^{13}C-NMR: see Tables I and II.

Acetylation of 6——**6** (20 mg) was acetylated under the same conditions as described for **4**, and the diacetate (**7**) (22 mg) was obtained as an amorphous powder, mp 98—102 °C, $[\alpha]_D$ −6.8° (c=1.00, MeOH). *Anal.* Calcd for $C_{45}H_{66}O_{16}$: C, 62.65; H, 7.66. Found: C, 62.80; H, 7.82. IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 1720, 1700, 1350, 1290, 1180, 1080. FD-MS m/z: 863 (M^++1). ^{1}H-NMR ($CDCl_3$) δ: 0.92 (3H, s, 19-CH_3), 1.26 and 1.29 (6H, br d, J=6.1 Hz and 3H, d, J=6.4 Hz, 6′-, 6″-, and 6‴-CH), 1.53 (3H, s, 21-CH_3), 2.09 (3H, s, –OCO·CH_3), 3.33 and 3.42 (each 3H, 3′- and 3‴-OCH_3), 3.85 (1H, dd, J=10, 9 Hz, 15-CH_β), 4.16 (1H, dd, J=9, 7 Hz, 15-CH_α), 4.53 (1H, dd, J=10, 2 Hz, 1′-CH), 4.63 (1H, t, J=9.5 Hz, 4‴-CH), 4.93 (1H, dd, J=10, 2 Hz, 1″-CH), 4.96 (1H, br d, J=3 Hz, 1‴-CH), 5.28 (2H, m, 3″-CH, and 16-CH), 5.39 (1H, d, J=5.2 Hz, 6-CH), 6.25 (1H, s, 18-CH).

Acidic Hydrolysis of 6——A solution of **6** (65 mg) in 5 ml of dioxane was treated with 4 ml of 0.1 N H_2SO_4 and the mixture was kept at 50 °C for 1 h, then subjected to acidic hydrolysis as described for **3** to give **19** (17 mg) and **20** (3 mg). Oleandrose and digitoxose were identified by TLC comparison with an authentic sample.

Compound 19——Colorless needles, mp 204—206 °C, $[\alpha]_D$ +82.0° (c=1.00, MeOH). *Anal.* Calcd for $C_{21}H_{28}O_5$: C, 69.97; H, 7.83. Found; C, 69.70; H, 7.78. IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3600, 1680, 1490, 1390, 1330, 1180, 1000, 900. FD-MS m/z: 360 (M^+). ^{1}H-NMR ($CDCl_3$): 0.94 (3H, s, 19-CH_3), 1.54 (3H, s, 21-CH_3), 3.44 (1H, dd, J=8, 2 Hz, 9, 7 Hz, 15-CH_α), 5.31 (1H, ddd, J=10, 8, 7 Hz, 16-CH), 5.40 (1H, d, J=5 Hz, 6-CH), and 6.26 (1H, d, J=2 Hz, 18-CH). These data were identical with those of glaucogenin-C (**1**).

Compound 20——Colorless fine needles, mp 207—210 °C, $[\alpha]_D$ +13° (c=1.00, MeOH). FD-MS m/z: 504 (M^+).

IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3600, 1680, 1490, 1450, 1390, 1180, 900. ^{1}H-NMR ($CDCl_3$) δ: 0.92 (3H, s, 19-CH_3), 1.33 (3H, d, J=5.8 Hz, 6′-CH_3), 1.53 (3H, s, 21-CH_3), 3.39 (3H, s, 3′-OCH_3), 3.85 (1H, dd, J=10, 9 Hz, 15-CH_β), 4.16 (1H, dd, J=9, 7 Hz, 15-CH_α), 4.59 (1H, dd, J=11, 3 Hz, 1′-CH), 5.30 (1H, ddd, J=10, 8, 7 Hz, 16-CH), 5.40 (1H, d, J=5.4 Hz, 6-CH), 6.25 (1H, br s, 18-CH). These data were identical with those of cynatratoside-A (**3**).

Isolation of 8 and 9——The benzene-insoluble portion (55 g) of the crude glycoside was applied to a silica gel (350 g of Wakogel C-200) column with solvents of increasing polarity from $CHCl_3$ to $CHCl_3$–MeOH (3:2) to give six fractions. Fraction 5 (20 g), containing mainly polar glycosides, was rechromatographed on columns of silica gel and MCI GEL (CHP 20P) with MeOH–$CHCl_3$ (1:9) and MeOH–H_2O (9:1), respectively, to give a fraction (1 g) containing mainly **8** and **9**, which were separated on a reversed RP-8 column with MeOH–H_2O (3:7 to give **8** (230 mg) and **9** (220 mg).

Cynatratoside-D (8)——An amorphous powder, mp 140—145 °C, $[\alpha]_D$ −25.8° (c=1.00, MeOH). *Anal.* Calcd for $C_{47}H_{72}O_{19}\cdot 1/2H_2O$: C, 58.31; H, 7.81. Found: C, 58.22; H, 7.66. IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3600, 3200, 1730, 1390, 1230, 1100. FD-MS m/z: 963 (M^++Na), 941 (M^++H), 633 (M^+−glaucobiose), 503 (M^+−glaucobiose–digitoxose). ^{1}H-NMR ($CDCl_3$) δ: 0.93 (3H, s, 19-CH_3), 1.25 and 1.30 (6H, br s, J=5.9 Hz and 3H, d, J=5.8 Hz, 6′, 6″-, and 6‴-CH_3), 1.54 (3H, s, 21-CH_3), 3.40 and 3.42 (each 3H, s, 3′- and 3‴-OCH_3), 4.21 (1H, dd, J=9, 7 Hz, 15-CH_α), 4.36 (1H, d, J=6.8 Hz, 1⁗-CH), 4.56 (1H, dd, J=10, 2 Hz, 1′-CH), 4.99 (1H, br s, 1‴-CH), 5.08 (1H, dd, J=9, 2 Hz, 1″-CH), 5.31 (1H, ddd, J=10, 8, 7 Hz, 16-CH), 5.43 (1H, br d, J=5 Hz, 6-CH), 6.26 (1H, d, J=2 Hz, 18-CH). ^{13}C-NMR: see Tables I and II.

Acidic Hydrolysis of 8——A solution of **8** (5 mg) in 1 ml of MeOH was treated with 2 ml of 0.05 N H_2SO_4 and the mixture was kept at 60 °C for 1 h, then subjected to acid hydrolysis as described for **4**; the products, **1**, **3**, cymarose, digitoxose and glaucobiose (**14**), were identified by TLC comparison with authentic samples.

Enzymatic Hydrolysis of 8——A powder of snail digestive juice (100 mg) was added to a suspension of **8** (100 mg) in 8 ml of 0.3 M NaOAc buffer adjusted to pH 5.5. The suspension was allowed to stand at 37 °C for 112 h. TLC analysis with MeOH–$CHCl_3$ (1:9) revealed the formation of **21** (*Rf*: 0.54). The solution was concentrated and glucose was detected by TLC analysis with MeOH–$CHCl_3$–H_2O (3:4:1; lower phase, *Rf*: 0.45). Then, 30 ml of $CHCl_3$ was added to the residue and the precipitate was filtered off. The filtrate was concentrated and chromatographed on a column of silica gel (16 g of Wakogel C-200) with 2% MeOH–$CHCl_3$ to give 65 mg of **21**.

Compound 21——An amorphous powder, mp 98—103 °C, $[\alpha]_D$ −20.2° (c=1.00, MeOH). *Anal.* Calcd for $C_{41}H_{62}O_{14}\cdot H_2O$: C, 61.79; H, 8.10. Found: C, 62.05; H, 8.14. IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3550, 1730, 1655, 1450, 1380, 1305, 1160, 1130, 1110, 1080, 1050, 1010, 980. FD-MS m/z: 778 (M^+). ^{1}H-NMR ($CDCl_3$)δ: 0.92 (3H, s, 19-CH_3), 1.25, 1.26, and 1.30 (each 3H, d, J=6.4 Hz, 5.9 Hz and 5.9 Hz respectively, 6′-, 6″-, and 6‴-CH_3), 1.53 (3H, s, 21-CH_3), 3.40 3.42 (each 3H, s, 3′- and 3‴-OCH_3), 3.85 (1H, dd, J=10, 9 Hz, 15-CH_β), 4.07 (1H, m, 3″-CH), 4.15 (1H, dd, J=9, 7 Hz, 15-CH_α), 4.53 (1H, dd, J=10, 2 Hz, 1′-CH), 4.90 (1H, br d, J=3 Hz, 1‴-CH), 5.02 (1H, dd, J=10, 2 Hz, 1″-CH), 5.30 (1H, ddd, J=10, 8, 7 Hz, 16-CH), 5.39 (1H, d, J=5 Hz, 6-CH), and 6.25 (1H, br s, 18-CH). ^{13}C-NMR (25 MHz): 18.0, 18.4, 18.5, 18.8, 24.0, 24.8, 28.5, 30.1, 32.2, 36.5, 37.9, 38.5, 38.7, 39.1, 40.7, 53.3, 56.2, 56.8, 57.4, 67.0, 67.8, 67.9, 69.1, 71.7, 72.7, 75.5, 76.6, 77.6, 79.2, 79.7, 80.8, 83.1, 98.1, 98.3, 98.5, 114.3, 118.5, 120.5, 140.6, 143.8, and 175.4. These data were identical with those of cynatratoside-B (**4**).

Cynatratoside-E (9)——An amorphous powder, mp 150—155 °C, $[\alpha]_D$ −19.9° (c=1.00, MeOH). *Anal.* Calcd for $C_{47}H_{72}O_{19}\cdot 3/2H_2O$: C, 58.31; H, 7.81. Found: C, 58.22; H, 7.66. IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3600—3200, 1720 1700, 1380, 1355, 1300, 1160, 1100, 1080, 1050, 980. FD-MS: (M^++Na), 940 (M^+), 630, 503. ^{1}H-NMR ($CDCl_3$) δ: 0.93 (3H, s, 19-CH_3), 1.25 and 1.30 (6H, and 3H each d, J=6.4 Hz, 6′-, 6″-, and 6‴-CH_3), 1.54 (3H, s, 21-CH), 3.41 (6H, s, 3′- and 3‴-OCH_3), 4.11 (1H, m, 3″-CH), 4.17 (1H, dd, J=9, 7 Hz, 15-CH_α), 4.54 (2H, m, 1′- and 1⁗-CH), 5.00 (2H, br d, J=6 Hz, 1″-, and 1‴-CH), 5.32 (1H, ddd, J=10, 8, 7 Hz, 16-CH), 5.40 (1H, br d, J=5 Hz, 6-CH), and 6.26 (1H, br s, 18-CH). ^{13}C-NMR: see Tables I and II.

Enzymatic Hydrolysis of 9——**9** (100 mg) subjected to enzymatic hydrolysis as described for **8**. Glucose and **22** (63 mg) were obtained.

Compound 22——An amorphous powder, mp 106—110 °C, $[\alpha]_D$ −8.3° (c=1.00, MeOH). *Anal.* Calcd for $C_{41}H_{62}O_{14}\cdot 1/2H_2O$: C, 62.50; H, 8.06. Found: C, 62.47; H, 8.00. IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3600, 1700, 1680, 1490, 1390, 1340, 1280, 1185, 1135, 960, 900. FD-MS m/z: 778 (M^+), 634 (M^+−144), 504 (634−130), 360 (504−144). ^{1}H-NMR ($CDCl_3$) δ: 0.92 (3H, s, 19-CH_3), 1.26 and 1.29 (6H, br d, J=6.4 Hz, and 3H, d, J=6.4 Hz, 6′-, 6″-, and 6‴-CH_3), 1.53 (3H, s, 21-CH_3), 3.40 (6H, s, 3′- and 3‴-OCH_3), 3.84 (1H, dd, J=10, 9 Hz, 15-CH_β), 4.11 (1H, m, 3″-CH), 4.15 (1H, dd, J=9, 7 Hz, 15-CH_α), 4.53 (1H, dd, J=10, 2 Hz, 1′-CH), 5.03 (2H, br d, J=4.4 Hz, 1″- and 1‴-CH), 5.32 (1H, ddd, J=10, 8, 7 Hz, 16-CH), 5.39 (1H, br d, J=4.9 Hz, 6-CH), 6.25 (1H, br s, 18-CH). ^{13}C-NMR (25 MHz): 18.0, 18.4, 18.7, 18.8, 24.0, 28.5, 30.0, 30.1, 35.8, 36.5, 38.0, 38.7, 39.1, 39.9, 40.7, 53.3, 56.2, 57.0, 57.5, 67.8, 69.0, 69.5, 71.7, 75.6, 76.9, 77.6, 78.8, 79.2, 82.3, 83.2, 98.2, 98.6, 100.3, 114.4, 118.5, 120.5, 140.7, 143.8, and 175.4. These data were identical with those of cynatratoside-C (**6**).

Isolation and Identification of Cymarose, D-Digitoxose, D-Oleandrose, and L-Diginose——Hydrolysis of the crude glycoside fraction has been described. After extraction of the aglycone with Et_2O and $CHCl_3$ successively, the water layer was neutralized with sat. $Ba(OH)_2$ aq. and the precipitate was filtered off. The filtrate was concentrated and chromatographed on a column of silica gel (80 g of Wakogel C-200) with solvents of increasing polarity from MeOH–

$CHCl_3$ (2 : 98) to MeOH–$CHCl_3$ (1 : 9) to separate 4 fractions. Fraction 1 contained mainly cymarose, and fraction 2 contained oleandrose and diginose. Digitoxose was obtained from fraction 3 as needles. Fraction 1 and fraction 2 were rechromatographed on a column of silica gel (80 g of Wakogel C-200) with 30% AcOEt–hexane to give cymarose, from fraction 1, and oleandrose and diginose from fraction 2.

Digitoxose (650 mg); needles, mp 110—112 °C, $[\alpha]_D$ +47.8° (c=1.00, H_2O). MS m/z: 148 (M^+), 131 ($M^+ - OH$), 112 ($M^+ - 2H_2O$), 97 (112-CH_3). A 0.2 N H_2SO_4–MeOH solution (3 ml) was added to a solution of 150 mg digitoxose in 3 ml of MeOH, and the mixture was stirred for 10 min. The solution was neutralized by addition of $Ba(OH)_2$ aq. and the precipitate was filtered off. The filtrate was concentrated and chromatographed on a column of silica gel (16 g of Wakogel C-300) with $CHCl_3$–acetone (3 : 1) to give methyl α-D-digitoxopyranoside (15 mg), methyl β-D-digitoxopyranoside (20 mg), methyl β-D-digitoxofuranoside (20 mg) and methyl α-D-digitoxofuranoside (17 mg). The ^{1}H-NMR data for these four compounds were identical with the reported values.[7]

Cymarose (700 mg); colorless syrup, $[\alpha]_D$ −40° (c=1.00, H_2O). MS m/z: 162 (M^+). The structure was confirmed by comparison of the ^{1}H-NMR data for the methyl α- and β-cymarofuranosides with those reported.[8]

D-Oleandrose (600 mg); a colorless syrup, $[\alpha]_D$ −10.2° (c=1.00, H_2O). MS m/z: 145 ($M^+ - OH$). The structure was confirmed by comparison of the ^{1}H-NMR data for the methyl α- and β-oleandropyranosides with those reported.[9] In addition to the above oleandropyranosides, one methyl oleandrofuranoside was obtained. ^{1}H-NMR data ($CDCl_3$) δ: 1.29 (3H, d, J=6.1 Hz, 6-CH_3), 1.12 (2H, m, 2-CH), 3.31 and 3.33 (each 3H, s, 1- and 3-OCH_3), 3.76 (1H, dd, J=5.2, 6.3 Hz, 5-CH), 3.90 (1H, m, 3-CH), 4.20 (1H, dd, J=7.5 Hz, 4-CH), and 5.11 (1H, dd, J=4.1, 6 Hz, 1-CH).

L-Diginose; needles, mp 86—89 °C, $[\alpha]_D$ −60.7° (c=1.00, H_2O). MS m/z: 145 ($M^+ - OH$). Methylation of this diginose gave both methyl α- and β-diginofuranosides and α- and β-diginopyranosides which were separated by column chromatography on silica gel. The structures were confirmed by comparison of the ^{1}H-NMR data with the reported values.[1]

For TLC analysis, three solvent systems were used: solvent A, $CHCl_3$–MeOH (9 : 1); solvent B, AcOEt–hexane (3 : 1); solvent C, acetone–petroleum ether (2 : 3). The *Rf* values of **1**, **3**, cymarose, oleandrose, diginose and digitoxose were 0.88, 0.86, 0.42, 0.40 and 0.20 with solvent A, 0.65, 0.59, 0.15, 0.14, 0.11, and 0.07 with solvent B, and 0.81, 0.80, 0.48, 0.44, 0.33, and 0.19, with solvent C, respectively.

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References

1) Part LVII: S. Tsukamoto, K. Hayashi, and H. Mitsuhashi, *Tetrahedron*, **41** (1985), in press.
2) T.-W. Shie, M.-L. Liu, and T.-C. Luo, *Acta Pharm. Sinica*, **7**, 175 (1959).
3) T. Nakagawa, K. Hayashi, and H. Mitsuhashi, *Chem. Pharm. Bull.*, **31**, 870 (1983).
4) *a*) T. Nakagawa, K. Hayashi, K. Wada, and H. Mitsuhashi, *Tetrahedron*, **39**, 607 (1983); *b*) T. Nakagawa, K. Hayashi, and H. Mitsuhashi, *Chem. Pharm. Bull.*, **31**, 879 (1983); *c*) *Idem, ibid.*, **31**, 2244 (1983).
5) *a*) T. Tori, S. Seo, Y. Yoshimura, Y. Tomita, and H. Ishii, *Tetrahedron Lett.*, **1976**, 4167; *b*) R. Kasai, M. Suzuo, J. Asakawa, and O. Tanaka, *ibid.*, **1977**, 175; *c*) S. Seo, Y. Tomita, K. Tori, and Y. Yoshimura, *J. Am. Chem. Soc.*, **100**, 3331 (1978).
6) K. Wada, K. Hayashi, H. Mitsuhashi, and H. Bando, *Chem. Pharm. Bull.*, **30**, 3500 (1982).
7) A. Zeeck, *Liebigs Ann.*, **1975**, 2079.
8) C. Monneret, C. Conreur, and K.-H. Qui, *Carbohydr. Res.*, **65**, 35 (1978); J. S. Brimacombe, Z. Al-Hasan, and A. S. Mengech, *J. Chem. Soc., Perkin Trans. 1*, **1980**, 1800.
9) S. Yasuda and T. Matsumoto, *Tetrahedron Lett.*, **1969**, 4393.