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FIVE NEW PREGNANE GLYCOSIDES FROM *CYNANCHUM TAIWANIANUM*

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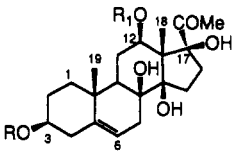
ABSTRACT.—Five new pregnane glycosides, taiwanosides A [**1**], B [**2**], C [**3**], D [**4**], and E [**5**], together with wilfosides C1N [**6**], C2N [**7**], M1N [**8**], and K1N [**9**], were isolated from the roots of *Cynanchum taiwanianum*. Their structures were determined on the basis of spectroscopic and chemical evidence.

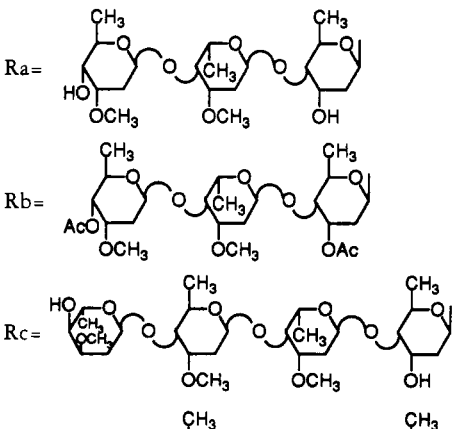
Species of the genus *Cynanchum* (Asclepiadaceae) have been studied extensively for their bioactive C/D-*cis*-polyoxypregnane glycoside constituents (1–19). The roots of *Cynanchum taiwanianum* Yamazaki have been used as a folk medicine for treating tumors in Taiwan. Chen *et al.* reported the isolation of flavones, β-amyrin, α-amyrin acetate, and taraxerol from the aerial parts of this plant (20). In connection with our interest in bioactive pregnane-type steroidal glycosides, chemical studies on the roots of this plant were undertaken. In this paper we describe the isolation and structural elucidation of five new glycosides, taiwanosides A [**1**], B [**2**], C [**3**], D [**4**], and E [**5**], together with four known pregnane glycosides, wilfosides C1N [**6**] (11), C2N [**7**] (11), M1N [**8**] (12), and K1N [**9**] (12).

RESULTS AND DISCUSSION

The EtOAc-soluble material from an EtOH extract of *C. taiwanianum* was chromatographed on Si gel to obtain a fraction rich in steroidal glycosides. Further



	R	R_1
1	Ra	Ac
1a	Rb	Ac
2	Rc	Ac
3	Rd	Ac
4	Rc	cinnamoyl
5	Rc	H
6	Rd	ikemaoyl
7	Rc	ikemaoyl
8	Rd	H
9	Rd	cinnamoyl
10	H	Ac
11	H	cinnamoyl
12	H	H



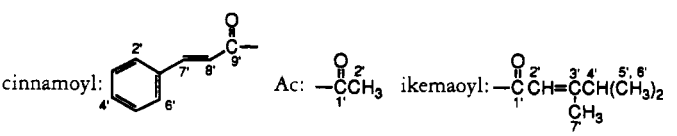


TABLE 1. ^{13}C-Nmr Chemical Shifts for the Aglycone Moieties of **1–5** and **10**.[a]

Carbon	Compound					
	1	**2**	**3**	**4**	**5**	**10**
1	39.3	39.3	39.2	39.5	39.6	38.8
2	29.9 (−2.0)[b]	29.9 (−2.0)[b]	29.7 (−2.2)[b]	29.9 (−2.0)[b]	29.9 (−0.6)[b]	31.9
3	77.77 (+6.1)[b]	77.7 (+6.1)[b]	77.7 (+6.1)[b]	77.7 (+6.1)[b]	77.8 (+6.1)[b]	71.6
4	38.9 (−4.1)[b]	38.9 (−4.1)[b]	38.9 (−4.1)[b]	39.0 (−4.5)[b]	39.0 (−4.5)[b]	43.0
5	139.4	139.4	139.3	139.5	139.4	140.1
6	119.1	119.1	119.0	119.1	119.4	118.4
7	33.7[c]	33.7[c]	33.8[c]	33.1[c]	32.8[c]	33.8[c]
8	74.4	74.4	74.5	74.4	74.3	74.1
9	44.5	44.5	44.4	44.6	44.9	44.2
10	37.4	37.4	37.3	37.4	37.4	37.0
11	24.8	24.8	24.7	25.1	29.4	25.0
12	73.6	73.5	73.9	73.6	68.9	73.0
13	57.9	57.9	58.3	58.1	60.4	57.6
14	89.4	89.4	89.3	89.5	89.3	89.1
15	34.7[c]	34.7[c]	34.6[c]	34.8[c]	35.1[c]	34.4[c]
16	32.8[c]	32.8[c]	32.7[c]	32.2[c]	32.4[c]	34.4[c]
17	92.4	92.4	92.3	92.4	92.5	92.1
18	10.4	10.4	10.3	10.7	9.4	10.1
19	18.6	18.2	18.4	18.4	18.6	18.0
20	210.1	210.1	210.9	209.9	209.6	209.9
21	27.6	27.6	27.5	27.7	27.9	27.0
1′	169.9	169.7	169.7	135.0		169.6
2′	20.8	20.8	20.7	128.9		20.6
3′				129.3		
4′				130.6		
5′				129.3		
6′				128.9		
7′				144.9		
8′				119.2		
9′				165.8		

[a]Measured at 75 MHz in C_5D_5N with TMS as internal standard.
[b]Values in parentheses represent glycosidation shifts.
[c]Indicated assignments in each column may be interchangeable.

separation of the constituents of this fraction by mplc on RP-18 led to the isolation of five new glycosides, taiwanosides A [**1**], B [**2**], C [**3**], D [**4**], and E [**5**], together with four known glycosides, wilfosides C1N, [**6**], C2N [**7**], M1N [**8**], and K1N [**9**]. The known compounds were identified by comparison of their physical and spectroscopic data with reported values (11,12). The new glycosides showed positive Liebermann-Burchard and Keller-Kiliani (21) reactions, which indicated the presence of steroidal glycosides with 2-deoxy sugars. Glycosidation shifts (22,23) were observed at C-2, C-3, and C-4 in each compound (Table 1), indicating that the sugar moiety in all cases is linked to the hydroxyl group at C-3. Among these new glycosides, **1–3** have the same aglycone, as indicated by their ^{1}H- and ^{13}C-nmr data (Table 1), and compounds **2**, **4**, and **5** have the same sugar chain as evidenced by their ^{1}H-, ^{13}C- (Table 2), nOe, and HMBC nmr data.

Taiwanoside A [**1**], isolated as white needles, mp 154–156°, $[\alpha]_D$ −46.2° (c=0.5, $CHCl_3$), has the molecular formula $C_{43}H_{68}O_{16}$ on the basis of fabms and elemental

TABLE 2. ^{13}C-Nmr Chemical Shifts for Sugar Moieties of **1–5**.[a]

Carbon		Compound				
		1	**2**	**3**	**4**	**5**
D-Cym	1			96.1		
	2			35.2		
	3			77.6[h]		
	4			82.2		
	5			69.1		
	6			18.7		
	3-OCH_3			57.2[f]		
D-Digito	1	96.4	96.4		96.5	96.4
	2	39.3	39.0		39.1	39.0
	3	68.7	68.7		68.9	68.7
	4	82.6	82.6[g]		82.7[g]	82.6[g]
	5	67.9[e]	67.9[e]		67.6[e]	67.9[e]
	6	18.8[d]	18.6[d]		18.7[d]	18.7[d]
L-Dig	1	100.8	100.8	100.8	100.9	100.8
	2	32.5[b]	32.4[b]	32.4[b]	32.3[b]	32.1[b]
	3	74.0[c]	73.9[c]	73.9[c]	74.4[c]	73.9[c]
	4	74.3[c]	74.3[c]	74.5[c]	74.1[c]	74.4[c]
	5	67.6[e]	67.5[e]	67.4	67.6[e]	67.5[e]
	6	17.8[d]	17.8[d]	17.8[d]	18.3[d]	17.8[d]
	3-OCH_3	55.1[f]	55.2[f]	55.3[f]	55.3[f]	55.2[f]
D-Cym	1	99.5	99.4	99.4	99.5	99.4
	2	36.3	36.3	36.3	36.4	36.3
	3	78.9	77.8	77.7[h]	77.9	77.7
	4	74.2[c]	82.3[g]	82.2	82.4[g]	82.3[g]
	5	71.0	69.4	69.3	69.5	69.4
	6	18.2[d]	18.4[d]	18.5[d]	17.9[d]	18.4[d]
	3-OCH_3	57.9[f]	58.3[f]	58.3[f]	58.3[f]	58.3[f]
L-Cym	1		99.0	98.9	99.1	99.0
	2		32.1[b]	32.0[b]	32.5[b]	32.1[b]
	3		76.4	76.3	76.5	76.4
	4		73.2[c]	73.1[c]	73.3[c]	73.2[c]
	5		66.5	66.3	66.6	66.4
	6		18.7[d]	18.1[d]	18.7[d]	18.6[d]
	3-OCH_3		56.5[f]	56.5[f]	56.7[f]	56.6[f]

[a]Measured at 75 MHz in C_5D_5N with TMS as an internal standard. D-Cym: β-D-cymaropyranosyl; D-digito: β-D-digitoxopyranosyl; L-Cym: α-L-cymaropyranosyl; L-dig: α-L-diginopyranosyl.

[b–h]Indicated assignments in each column may be interchangeable.

analysis and its ir spectrum showed hydroxyl (3400 cm^{-1}), carbonyl (1710 cm^{-1}), ester (1720 and 1220 cm^{-1}), and olefinic (3030 and 1630 cm^{-1}) group absorptions. The ^{1}H-nmr spectrum of **1** exhibited four methyl groups [δ 1.10, 1.40, 1.92, 2.22 (3H each, s, Me-19 and Me-18, AcO-12, Me-21)] and one olefinic proton [δ 5.33 (1H, br s, H-6)] in its aglycone moiety, and three secondary methyl groups [δ 1.22, 1.24, 1.28 (3H each, d, J=6.0 Hz)], together with two methoxyl signals [δ 3.38 (6H, s)] in its sugar moiety. One α- linkage and two β- linkages of sugars were revealed by the coupling constants of the anomeric proton signals at δ 4.66 (1H, dd, J=8.3 and 3.0 Hz), 4.92 (1H, dd, J=9.6 and 2.3 Hz), and 5.03 (1H, d, J=3.0 Hz). Mild acidic hydrolysis of **1** afforded a mixture of sugars and the aglycone **10**, which was identical with metaplexigenin (24–26). The ^{13}C-nmr data (Table 1) of **10** further confirmed the assigned structure. The ^{1}H- and ^{13}C-nmr data (Table 2) indicated that the three monosaccharides obtained were β-D-digitoxopyranose, α-L-diginopyranose, and β-D-cymaropyranose in taiwanoside A

[**1**]. The sugar sequence of **1** was suggested by nOe difference spectra and heteronuclear-correlated 2D nmr spectral (HMBC) data. Irradiation at δ 4.66 (H-1 of β-D-cymaropyranose) caused enhancements at δ 3.80 (1H, dq, J=9.0 and 6.2 Hz, H-5 of β-D-cymaropyranose) and δ 3.86 (1H, br s, H-4 of α-L-diginopyranose), which indicated that the cymarose was β-linked to diginose. Irradiation at δ 4.92 (1H, dd, J=9.6 and 2.3 Hz, H-1 of digitoxopyranose) caused nOes at δ 3.82 (1H, m, H-3) and 3.78 (1H, dq, J=9.3 and 6.2 Hz, H-5 of β-D-digitoxopyranose), which showed that digitoxose was β-linked to C-3 of the aglycone, and, based on the HMBC correlations between δ 5.03 (1H, d, J=3.1 Hz, H-1 of α-L-diginopyranose) and δ 82.6 (C-4 of β-D-digitoxopyranose), indicated that the diginose moiety was α-linked to the C-4 hydroxy group of digitoxose. Acetylation of **1** gave triacetate **1a** (δ 1.93, 1.96, and 1.98), and its ^{1}H-nmr spectrum showed a shift of the H-3 signal of β-D-digitoxose from δ 3.58 to 5.29 (1H, ddd, J=3.1, 2.8, and 2.8 Hz), and of the H-4 signal of β-D-cymarose from δ 3.26 (1H, dd, J=9.8 and 2.9 Hz) to 4.56 (1H, dd, J=9.8 and 3.0 Hz). Therefore, the structure of taiwanoside A [**1**] was deduced to be metaplexigenin 3-*O*-β-D-cymaropyranosyl-(1→4)-α-L-diginopyranosyl-(1→4)-β-D-digitoxopyranoside.

Taiwanoside B [**2**], colorless needles, mp 156–158°, [α]D −73.0° (c=1.0, $CHCl_3$), has the molecular formula $C_{50}H_{80}O_{19}$ on the basis of fabms and eims. Its ir spectrum exhibited the presence of hydroxyl (3450 cm^{-1}), olefinic (3030 and 1635 cm^{-1}), carbonyl (1710 cm^{-1}), and ester (1730 and 1230 cm^{-1}) groups. The ^{1}H-nmr spectrum of **2** gave signals at δ 1.10 (3H, s, Me-19), 1.40 (3H, s, Me-18), 1.96 (3H, s, AcO-12), 2.28 (3H, s, Me-21), and 5.32 (1H, br s, H-6) in its aglycone moiety, which were very similar to those of **1**. The sugar moiety contained four secondary methyl signals at δ 1.20, 1.21, 1.22, and 1.23 (3H each, d, J=6.3 Hz), three methoxyl methyl signals at δ 3.37, 3.39, and 3.40 (3H each, s), and four anomeric proton signals at δ 4.73 (1H, dd, J=10.2 and 2.1 Hz), 4.75 (1H, d, J=3.1 Hz), 4.90 (1H, dd, J=9.6 and 2.1 Hz), and 5.26 (1H, d, J=3.0 Hz), corresponding to carbon signals at δ 96.4, 99.0, 99.4, and 100.8 (Table 2). This indicated that there were four sugar units in **2** with two α-linkages and two β-linkages. The sugar sequence of **2** was also confirmed by nOe observations [irradiation at δ 4.73 (1H, dd, J=10.2 and 2.1 Hz, H-1 of β-D-cymaropyranose) caused enhancement at δ 3.85 (1H, br s, H-4 of α-L-diginopyranose), and irradiation at δ 4.90 (1H, dd, J=9.6 and 2.1 Hz, H-1 of β-D-digitoxopyranose) caused enhancement at δ 3.58 (1H, m, H-3)] and by HMBC nmr correlations [δ 4.75 (1H, d, J=3.1 Hz, H-1 of α-L-cymaropyranose) to δ 82.3 (C-4 of β-D-cymaropyranose), and δ 5.26 (1H, d, J=3.0 Hz, H-1 of α-L-diginopyranose) to δ 82.6 (C-4 of β-D-digitoxoyranose)]. In comparison with the terminal β-D-cymarose of **1** (Table 2), the glycosidation shifts of the β-D-cymaropyranose moiety in **2** were observed at C-3 (−1.1 ppm), C-4 (+8.1 ppm), and C-5 (−1.6 ppm), which indicated that the terminal α-L-cymaropyranose was linked to the C-4 hydroxyl group of β-D-cymaropyranose. Consequently, the structure of **2** was confirmed as metaplexigenin 3-*O*-α-L-cymaropyranosyl-(1→4)-β-D-cymaropyranosyl-(1→4)-α-L-diginopyranosyl-(1→4)-β-D-digitoxopyranoside.

Taiwanoside C [**3**], colorless needles, mp 153–155°, [α]D −55.0° (c=1.0, $CHCl_3$), has the molecular formula $C_{51}H_{82}O_{19}$ on the basis of fabms and eims. Its ^{1}H-nmr spectrum was similar to that of **2**, except that **3** had four methoxyl groups [δ 3.36, 3.37, 3.39, and 3.43 (3H each, s)] instead of three. There were also two α-linkages and two β-linkages of sugars as inferred from the coupling constants of the anomeric proton signals at δ 4.73 (1H, dd, J=9.6 and 2.1 Hz), 4.75 (1H, d, J=3.0 Hz), 4.79 (1H, dd, J=10.5 and 2.1 Hz), 4.95 (1H, d, J=3.0 Hz). Mild alkaline hydrolysis yielded the known compound **8** (12). Therefore, the structure of **3** was established as metaplexigenin 3-*O*-α-L-cymaropyranosyl-(1→4)-β-D-cymaropyranosyl-(1→4)-α-L-diginopyranosyl-(1→4)-β-D-cymaropyanoside.

Taiwanoside D [**4**], colorless needles, mp 162–164°, $[\alpha]_D$ −57.0° (c=1.0, $CHCl_3$), uv λ max (MeOH) (log ε) 278 (2.89), 223 (3.81), and 217 (3.84) nm, had a molecular formula of $C_{57}H_{84}O_{19}$ on the basis of fabms and eims. The ^{1}H-nmr spectrum of **4** showed a cinnamoyl group at δ 6.28 (1H, d, J=15.9 Hz), 7.36 (3H, m, H-3′, H-4′, H-5′), 7.49 (2H, m, H-2′, H-6′), and 7.59 (1H, d, J=15.9 Hz). Compound **4** had the same sugar chain as **2**, as indicated by their ^{13}C-nmr (Table 2) spectra obtained with nOe and HMBC experiments. Acid hydrolysis of **4** afforded a product which was identical with kidjoranine [**11**] (26,27). Based on the above evidence, the structure of **4** was deduced as kidjoranine 3-*O*-α-L-cymaropyranosyl-(1→4)-β-D-cymaropyranosyl-(1→4)-α-L-diginopyranosyl-(1→4)-β-D-digitoxopyranoside.

The ^{1}H-nmr spectrum of taiwanoside E [**5**] gave no evidence for an ester functional group in the aglycone moiety [δ 1.15, 1.19, and 2.26 (3H each, s), 1.17, 1.19, 1.21, and 1.22 (3H each, d, J=6.3 Hz), 3.33, 3.35, and 3.40 (3H each, s), 4.70 (1H, dd, J=9.8 and 2.1 Hz), 4.71 (1H, d, J=3.0 Hz), 4.86 (1H, dd, J=9.3 and 2.1 Hz), 4.98 (1H, d, J=3.0 Hz), 5.28 (1H, br s)]. The ^{13}C-nmr data (Table 2) of the sugar moiety were almost the same as those of **2** and **4**. Basic hydrolysis of compound **4** yielded compound **5** and cinnamic acid. Mild acidic hydrolysis of **5** yielded deacylmetaplexigenin [**12**] (26,28). Thus, the structure of **5** was assigned as deacylmetaplexigenin 3-*O*-α-L-cymaropyranosyl-(1→4)-β-D-cymaropyranosyl-(1→4)-α-L-diginopyranosyl-(1→4)-β-D-digitoxopyranoside.

EXPERIMENTAL

GENERAL EXPERIMENTAL PROCEDURES.—Mps were determined with Yanagimoto micro-melting point apparatus and are uncorrected. Ir spectra were recorded on a Perkin-Elmer 781 spectrophotometer. Uv spectra were measured on a Hitachi U-3200 spectrophotometer. Optical rotations were measured on a Jasco DIP-370 instrument. Fabms spectra were obtained on a JEOL SX-102A spectrometer. ^{1}H- and ^{13}C-nmr spectra were run on Bruker AC-300 and AMX 400 spectrometers, respectively.

PLANT MATERIAL.—The roots of *Cynanchum taiwanianum* were collected from Cha-Yi, Taiwan, in May 1993. Plant material was identified by Dr. Ih-Sheng Chen, School of Pharmacy, Kaohsiung Medical College, and a voucher specimen has been deposited at the Herbarium of the Department of Botany of National Taiwan University, Taipei, Taiwan.

EXTRACTION AND ISOLATION.—The roots of *C. taiwanianum* (5 kg) were extracted twice with EtOH (30 liters) at ca. 50°. The EtOH extract was evaporated *in vacuo*, yielding a black residue, which was taken up in H_2O (1 liter). The aqueous solution was partitioned with successively EtOAc and *n*-BuOH. The EtOAc fraction was evaporated to dryness, and repeated separation and purification on Si gel and reversed-phase gel cc afforded nine pregnane oligoglycosides, including five new compounds, taiwanosides A [**1**] (56 mg), B [**2**] (275 mg), C [**3**] (5.895 g), D [**4**] (187 mg), and E [**5**] (85 mg), together with four known compounds, wilfosides C1N [**6**] (985 mg), C2N [**7**] (270 mg), M1N [**8**] (482 mg), and K1N [**9**] (124 mg).

Taiwanoside A [**1**].—Mp 154°; $[\alpha]_D$ −46.2° (c=0.5, $CHCl_3$); ir (KBr) ν max 3400, 3030, 2935, 2900, 1720, 1710, 1630, 1220, 1065, 1040, 1000 cm^{-1}; ^{1}H nmr ($CDCl_3$) δ 1.10 (3H, s, Me-19), 1.22, 1.24, 1.28 (3H each, d, J=6.0 Hz, Me-6 of sugars), 1.40 (3H, s, Me-18), 1.92 (3H, s, AcO-12), 2.22 (3H, s, Me-21), 3.26 (1H, dd, J=9.8 and 2.9 Hz, H-4 of β-D-cymaropyranose), 3.27 (1H, dd, J=9.6 and 3.0 Hz, H-4 of β-D-digitoxopyranose), 3.38 (6H, s, MeO-3 of sugar moiety), 3.78 (1H, dq, J=9.3 and 6.2 Hz, H-5 of β-D-digitoxopyranose), 3.80 (1H, dq, J=9.0 and 6.2 Hz, H-5 of β-D-digitoxopyranose), 3.82 (1H, m, H-3 of aglycone), 3.86 (1H, br s, H-4 of α-L-diginopyranose), 4.66 (1H, dd, J=8.3 and 3.0 Hz, anomeric H), 4.92 (1H, dd, J=9.6 and 2.3 Hz, anomeric H), 5.03 (1H, d, J=3.1 Hz, anomeric H), 5.33 (1H, br s, H-6 of aglycone); ^{13}C-nmr data, see Table 1; *anal.*, found C, 61.32, H, 8.10%, $C_{43}H_{68}O_{16}$ requires C, 61.44, H, 8.09; fabms *m/z* 839 $(M-H)^-$.

Taiwanoside B [**2**].—Mp 156–158°; $[\alpha]_D$ −73.0° (c=1.0, $CHCl_3$); ir (KBr) ν max 3450, 3030, 2985, 2930, 1730, 1710, 1635, 1230, 1055, 1020 cm^{-1}; ^{1}H nmr ($CDCl_3$) δ 1.10 (3H, s, Me-19), 1.20, 1.21, 1.22, 1.23 (3H each, d, J=6.3 Hz, Me-6 of sugars), 1.40 (3H, s, Me-18), 1.96 (3H, s, AcO-12), 2.28 (3H, s, Me-21), 3.24 (1H, dd, J=9.4 and 2.7 Hz, H-4 of β-D-cymaropyranose), 3.28 (1H, dd, J=9.5 and 2.3 Hz, H-4 of β-D-digitoxopyranose), 3.37, 3.39, 3.40 (3H each, s, MeO-3 of sugar moiety), 3.57 (1H, dd, J=9.3 and 2.4 Hz, H-4 of α-L-cymaropyranose), 3.58 (1H, m, H-3 of aglycone), 3.85 (1H, br s, H-4 of α-L-

diginopyranose), 4.73 (1H, dd, J=10.2 and 2.1 Hz, anomeric H), 4.75 (1H, d, J=3.1 Hz, anomeric H), 4.90 (1H, dd, J=9.6 and 2.1 Hz, anomeric H), 5.26 (1H, d, J=3.0 Hz, anomeric H), 5.32 (1H, br s, H-6); ^{13}C-nmr data, see Table 1; *anal.*, found C, 61.02, H, 8.08, $C_{50}H_{80}O_{19}$ requires C, 60.97, H, 8.13; fabms *m/z* 983 $(M-H)^-$.

Taiwanoside C [**3**].—Mp 153–155°; $[\alpha]_D$ −55.0° (c=1.0, $CHCl_3$); ir (KBr) ν max 3440, 3010, 2940, 2900, 1725, 1700, 1630, 1220, 1080, 1060, 1000 cm^{-1}; ^{1}H nmr ($CDCl_3$) δ 1.09 (3H, s, Me-19), 1.18, 1.20, 1.20, 1.22 (3H each, d, J=6.3 Hz, Me-6 of sugars), 1.39 (3H, s, Me-18), 1.91 (3H, s, AcO-12), 2.21 (3H, s, Me-21), 3.36, 3.37, 3.39, 3.43 (3H each, s, MeO-3 of sugar moiety), 3.25 (1H, dd, J=9.6 and 3.0 Hz, H-4 of β-D-cymaropyranose), 3.55 (1H, dd, J=10.2 and 2.7 Hz, H-4 of α-L-cymaropyranose), 3.80 (1H, m, H-3 of aglycone), 4.73 (1H, dd, J=9.6 and 2.1 Hz, anomeric H), 4.75 (1H, d, J=3.0 Hz, anomeric H), 4.79 (1H, dd, J=10.5 and 2.1 Hz, anomeric H), 4.95 (1H, d, J=3.0 Hz, anomeric H), 5.32 (1H, br s, H-6); ^{13}C-nmr data, see Table 1; *anal.*, found C, 61.44, H, 8.16, $C_{51}H_{82}O_{19}$ requires C, 61.32, H, 8.22; fabms *m/z* 997 $(M-H)^-$.

Taiwanoside D [**4**].—Mp 165–167°; $[\alpha]_D$ −25.0° (c=1.0, $CHCl_3$); ir (KBr) ν max 3450, 3020, 2940, 2910, 1710, 1635, 1490, 1450, 1260, 1200, 1080, 1060, 1000 cm^{-1}; uv λ max (MeOH) (log ε) 278 (2.89), 223 (3.81), 217 (3.84) nm; ^{1}H nmr ($CDCl_3$) δ 1.12 (3H, s, Me-19), 1.21, 1.21, 1.22, 1.23 (3H each, d, J=6.6 Hz, Me-6 of sugars), 1.45 (3H, s, Me-18), 2.18 (3H, s, Me-21), 3.25 (1H, dd, J=9.6 and 2.4 Hz, H-4 of β-D-cymaropyranose), 3.27 (1H, dd, J=9.5 and 2.7 Hz, H-4 of β-D-digitoxopyranose), 3.37, 3.40, 3.44 (3H each, s, MeO-3 of sugar moiety), 3.50 (1H, dd, J=9.3 and 2.4 Hz, α-L-cymaropyranose), 3.51 (1H, m, H-3 of aglycone), 3.82 (1H, br s, H-4 of α-L-diginopyranose), 4.75 (1H, dd, J=10.5 and 2.1 Hz, anomeric H), 4.77 (1H, d, J=3.1 Hz, anomeric H), 4.92 (1H, dd, J=10.5 and 3.0 Hz, anomeric H), 5.03 (1H, d, J=3.0 Hz, anomeric H), 5.34 (1H, br s, H-6), 6.28 (1H, d, J=15.9 Hz, H-8′), 7.36 (3H, m, H-3′, H-4′, and H-5′), 7.49 (2H, m, H-2′, H-6′), 7.59 (1H, d, J=15.9 Hz, H-7′); ^{13}C-nmr data, see Table 1; *anal.*, found C, 63.95, H, 7.80, $C_{57}H_{84}O_{19}$ requires C, 63.81, H, 7.84; fabms *m/z* 1071 $(M-H)^-$.

Taiwanoside E [**5**].—Mp 156–157°; $[\alpha]_D$ −68.0° (c=1.0, $CHCl_3$); ir (KBr) ν max 3400, 3030, 2940, 2900, 1700, 1630, 1430, 1370, 1080, 1050, 1000 cm^{-1}; ^{1}H nmr ($CDCl_3$) δ 1.15 (3H, s, Me-19), 1.17, 1.19, 1.21, 1.22 (3H each, d, J=6.3 Hz, Me-6 of sugars), 1.20 (3H, s, Me-18), 2.26 (3H, s, Me-21), 3.33, 3.35, 3.40 (3H each, s, MeO-3 of sugar moiety), 4.70 (1H, dd, J=9.8 and 2.1 Hz, anomeric H), 4.71 (1H, d, J=3.0 Hz, anomeric H), 4.86 (1H, dd, J=9.3 and 2.1 Hz, anomeric H), 4.98 (1H, d, J=3.0 Hz, anomeric H), 5.28 (1H, br s, H-6); ^{13}C-nmr data, see Table 1; *anal.*, found C, 61.35, H, 8.21%, $C_{48}H_{78}O_{18}$ requires C, 61.15, H, 8.28%, fabms *m/z* 941 $(M-H)^-$.

ACIDIC HYDROLYSIS OF TAIWANOSIDE A [**1**].—Compound **1** (10 mg) was heated in methanolic 2% H_2SO_4 (5 ml) at 50° for 1 h, then H_2O (5 ml) was added and the whole mixture was concentrated to about 3 ml, and neutralized with saturated $Ba(OH)_2$. The precipitates were filtered off and the filtrate was evaporated to dryness. The residue was purified over Si gel using 5% MeOH/$CHCl_3$ to afford metaplexigenin [**10**] (4 mg) [colorless needles, mp 273–276°; eims *m/z* 422 (M^+)] and a sugar mixture (4 mg).

ACETYLATION OF **1**.—A solution of taiwanoside A [**1**] (5 mg) in pyridine (0.5 ml) and Ac_2O (0.5 ml) was left at room temperature for 1 day. The reaction mixture was treated in the usual manner and purified by Si gel cc ($CHCl_3$) to yield a triacetate [**1a**] (5 mg) (amorphous); ir (KBr) ν max 3450, 3020, 2980, 2960, 1740, 1710, 1630, 1240, 1055, 1020 cm^{-1}; ^{1}H nmr ($CDCl_3$) δ 1.10, 1.40, 1.93, 1.96, 1.98 (3H each, s), 1.14, 1.15, 1.70 (3H each, d, J=6.6 Hz), 2.22 (3H, s), 3.40 (6H, s), 3.83 (1H, m), 4.55 (1H, dd, J=9.9 and 3.0 Hz), 4.56 (1H, dd, J=9.8 and 3.0 Hz), 4.70 (1H, dd, J=9.3 and 2.3 Hz), 4.97 (1H, d, J=3.0 Hz), 5.29 (1H, ddd, J=3.1, 2.8 and 2.8 Hz), 5.30 (1H, br s).

ALKALINE HYDROLYSIS OF **3**.—Taiwanoside C [**3**] (10 mg) was dissolved in 5% methanolic NaOH (2 ml) at room temperature overnight. After addition of H_2O (2 ml), the MeOH was removed under reduced pressure. The aqueous concentrate was extracted with EtOAc, the EtOAc extract was dried over Na_2SO_4, filtered and evaporated to dryness, and afforded a product that was identical to wilfoside M1N [**8**] (12) (4 mg) [mp 151–153°].

ACIDIC HYDROLYSIS OF **4**.—Compound **4** (10 mg) was heated in methanolic 2% H_2SO_4 (5 ml) at 50° for 1 h, then worked up as above, yielding kidjoranine [**11**] (26,27) (4 mg) (mp 150–152°) and a sugar mixture (4 mg).

BASIC HYDROLYSIS OF **4**.—Taiwanoside D [**4**] (20 mg) and NaOH (100 mg) were heated in 4 ml of a 50% aqueous MeOH solution for 6 h. After addition of H_2O (25 ml), the solution was extracted with EtOAc to give organic and aqueous layers. The organic layer yielded compound **5** (15 mg) and the aqueous layer afforded cinnamic acid (2 mg) after purification.

ACIDIC HYDROLYSIS OF **5**.—Compound **5** (10 mg) was heated in methanolic 2% H_2SO_4 (5 ml) at 50° for 1 h, then worked up as above to give deacylmetaplexigenin **[12]** (26,28) (3 mg) (mp 218–222°).

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LITERATURE CITED

1. Z.X. Zhang, J. Zhou, K. Hayashi, and H. Mitsuhashi, *Chem. Pharm. Bull.*, **33**, 1507 (1985).
2. Z.X. Zhang, J. Zhou, K. Hayashi, and H. Mitsuhashi, *Chem. Pharm. Bull.*, **33**, 4188 (1985).
3. Z.X. Zhang, J. Zhou, K. Hayashi, and K. Kaneko, *Phytochemistry*, **27**, 2935 (1988).
4. T. Nakagawa, K. Hayashi, and H. Mitsuhashi, *Chem. Pharm. Bull.*, **31**, 870 (1983).
5. T. Nakagawa, K. Hayashi, and H. Mitsuhashi, *Chem. Pharm. Bull.*, **31**, 879 (1983).
6. T. Nakagawa, K. Hayashi, K. Wada, and H. Mitsuhashi, *Tetrahedron*, **39**, 607 (1983).
7. T. Nakagawa, K. Hayashi, and H. Mitsuhashi, *Chem. Pharm. Bull.*, **31**, 2244 (1983).
8. K. Sugama, K. Hayashi, H. Mitsuhashi, and K. Kaneko, *Chem. Pharm. Bull.*, **34**, 4500 (1986).
9. K. Sugama and K. Hayashi, *Phytochemistry*, **27**, 3984 (1988).
10. K. Hayashi, K. Wada, H. Mitsuhashi, H. Bando, M. Takase, S. Terada, Y. Koide, T. Aiba, T. Narita, and D.I. Mizuno, *Chem. Pharm. Bull.*, **28**, 1954 (1980).
11. S. Tsukamoto, K. Hayashi, and H. Mitsuhashi, *Tetrahedron*, **41**, 927 (1985).
12. S. Tsukamoto, K. Hayashi, and H. Mitszhashi, *Chem. Pharm. Bull.*, **33**, 2294 (1985).
13. K. Hayashi and H. Mitsuhashi, *Chem. Pharm. Bull.*, **23**, 139 (1975).
14. S. Tsukamoto, K. Hayashi, H. Mitsuhashi, F.O. Snyckers, and T.G. Fourie, *Chem. Pharm. Bull.*, **33**, 4807 (1985).
15. S. Tsukamoto, K. Hayashi, K. Kaneko, H. Mitsuhashi, F.O. Snyckers, and T.G. Fourie, *Chem. Pharm. Bull.*, **34**, 1337 (1986).
16. T. Yamagi, K. Hayashi, and H. Mitsuhashi, *Chem. Pharm. Bull.*, **20**, 2289 (1972).
17. K. Wada, K. Hayashi, H. Mitsuhashi, and H. Bando, *Chem. Pharm. Bull.*, **27**, 2252 (1979).
18. K. Wada, K. Hayashi, H. Mitsuhashi, and H. Bando, *Chem. Pharm. Bull.*, **30**, 3500 (1982).
19. S. Tsukamoto, K. Hayashi, and K. Kaneko, *J. Chem. Soc., Perkin Trans. I*, 2621 (1988).
20. Z.S. Chen, J.S. Lai, and Y.H. Kuo, *J. Chin. Chem. Soc.*, **38**, 393 (1991).
21. J. VonEuw and T. Reichstein, *Helv. Chim. Acta*, **31**, 883 (1948).
22. R. Kasai, M. Suzuo, J. Asakawa, and O. Tanaka, *Tetrahedron Lett.*, 175 (1977).
23. S. Seo, Y. Tomita, K. Tori, and Y. Yoshimura, *J. Am. Chem. Soc.*, **100**, 3331 (1978).
24. H. Mitshuhasi and T. Nomura, *Chem. Pharm. Bull.*, **13**, 274 (1965).
25. H. Mitshuhasi and T. Nomura, *Chem. Pharm. Bull.*, **11**, 1333 (1963).
26. S.S. Gong, C.D. Liu, S.L. Liu, Y.R. Du, W. Kang, and X.Q. Dong, *Acta Pharm. Sin.*, **23**, 276 (1988).
27. T. Sasaki, K. Hayashi, and H. Mitsuhashi, *Chem. Pharm. Bull.*, **20**, 628 (1972).
28. H. Mitsuhasi, K. Sakurai, T. Nomura, and N. Kawahara, *Chem. Pharm. Bull.*, **14**, 712 (1966).

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