Cassane- and Norcassane-Type Diterpenes of *Caesalpinia crista* from Myanmar

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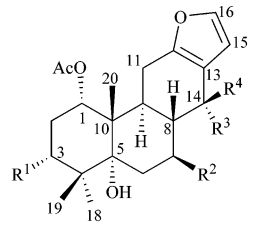
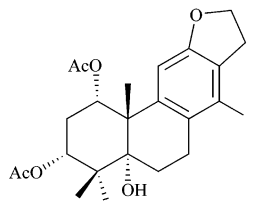
From the CH_2Cl_2 extract of seed kernels of *Caesalpinia crista* from Myanmar, five new cassane-type diterpenes, caesalpinins MA−ME (**1**−**5**), and three new norcassane-type diterpenes, norcaesalpinins MA−MC (**6**−**8**), have been isolated, together with 12 known cassane-type diterpenes, 14(17)-dehydrocaesalmin F, caesaldekarin e, caesalmin B, caesalmin C, caesalmin E, 2-acetoxy-3-deacetoxycaesaldekarin e, 2-acetoxycaesaldekarin e, caesalpinin C, 7-acetoxybonducellpin C, caesalpinin E, norcaesalpinin B, and 6-acetoxy-3-deacetoxycaesaldekarin e. The structures of the isolated compounds were elucidated by analysis of their spectroscopic data.

Caesalpinia crista L. (Fabaceae) is a well-known medicinal plant widely distributed in tropical and subtropical regions of Southeast Asia. This plant is locally known as "Ka-Lain" in Myanmar, and its seeds are used as an anthelmintic, antipyretic, antiinflammatory, and antimalarial agent.[1] In Indonesia, it is known as "Bagore", and a decoction of its roots has been used as a tonic and for the treatment of rheumatism and backache.[2] This plant, as a member of the genus *Caesalpinia*, is a rich source of cassane-type furanoditerpenes and is reported to have antimalarial,[3,4] antiviral,[5] and anticancer[6] activities. In our previous report on *C. crista* from Indonesia, we reported 10 new cassane- and norcassane-type furanoditerpenes.[4] Recently, in a continuing study on *C. crista*, we have examined the chemical constituents of the CH_2Cl_2 extract of seed kernels of this plant from Myanmar and isolated five new cassane-type diterpenes (**1**−**5**) and three new norcassane-type diterpenes (**6**−**8**) together with 12 known diterpenes. In this paper, we report the structure elucidation of these new cassane- and norcassane-type diterpenes.



1 R^1 = OAc, R^2 = R^4 = H, R^3 = CH_3
2 R^1 = R^2 = R^3 = H, R^4 = $COOCH_3$
9 R^1 = R^3 = H, R^2 = OAc, R^4 = $COOCH_3$



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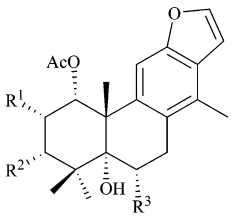
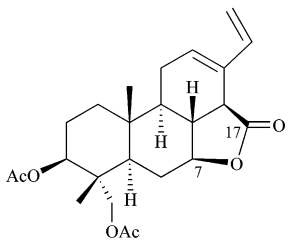


4 R^1 = R^3 = OAc, R^2 = H
10 R^1 = R^2 = OAc, R^3 = H
11 R^1 = R^3 = H, R^2 = OAc



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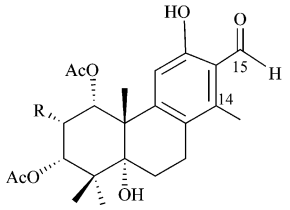
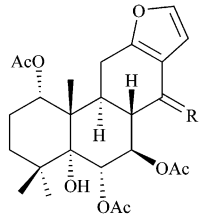


6 R = H
7 R = OAc



8 R = O
12 R = CH_2

Results and Discussion

Air-dried seed kernels of *C. crista* were extracted with CH_2Cl_2 by overnight percolation at room temperature. The CH_2Cl_2 extract was first fractionated by silica gel column chromatography with a benzene/EtOAc gradient solvent system into seven fractions. Then, fractions 2 and 3 were further subjected to repeated silica gel column chromatography, followed by normal- and reversed-phase preparative TLC, to afford five new cassane-type diterpenes, caesalpinins MA−ME (**1**−**5**), and three new norcassane-type diterpenes, norcaesalpinins MA−MC (**6**−**8**), together with 12 known diterpenes, 14(17)-dehydrocaesalmin F,[7] caesaldekarin e,[8] caesalmin B,[9] caesalmin C,[5] caesalmin E,[5] 2-acetoxy-3-deacetoxycaesaldekarin e,[10] 2-acetoxycaesaldekarin e,[7] caesalpinin C,[4] 7-acetoxybonducellpin C,[11] caesalpinin E,[4] norcaesalpinin B,[3,4] and 6-acetoxy-3-deacetoxycaesaldekarin e.[12]

Caesalpinin MA (**1**) was isolated as a colorless amorphous solid with $[\alpha]_D^{25}$ −12.6° ($CHCl_3$), and its molecular formula was determined to be $C_{24}H_{34}O_6$ by HRFABMS. IR absorptions at 3650 and 1730 cm^{-1} indicated the presence of hydroxyl and carbonyl groups, respectively. The ^1H NMR spectrum of **1** (Table 1) displayed signals corresponding to three tertiary methyls and a secondary methyl, two oxygen-substituted methines, three aliphatic methines together with two protons of a 1,2-disubstituted furan ring (δ 7.22, 6.19), and two acetyl methyls. Moreover, the ^{13}C NMR spectrum of **1** showed four olefinic carbons (δ 148.7, 140.6, 122.8, 109.6) and three oxygen-substituted carbons (δ 77.2, 77.0, 74.0) together with two ester carbonyl carbons (δ 169.3). Analysis of the COSY spectrum led to the partial structures depicted by the bold lines in Figure 1a, which were connected on the basis of the long-range correlations observed in the HMBC spectrum. The locations of the acetyl groups were determined to be at C-1 and C-3, on the basis of the long-range correlations of the ester carbonyl carbon at δ 169.3 (OCO-1) with the protons at δ 2.05 ($OCOCH_3$-1) and 4.85 (H-1) and of the ester carbonyl at δ

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Table 1. ^{1}H NMR (400 MHz) and ^{13}C NMR (100 MHz) Data (δ) for Compounds **1**−**4** in $CDCl_3$ (*J* values in parentheses)

	1		**2**		**3**		**4**	
position	^{1}H	^{13}C	^{1}H	^{13}C	^{1}H	^{13}C	^{1}H	^{13}C
1	4.85 t (2.9)	74.0	4.87 t (2.6)	75.8	5.59 t (2.9)	73.5	5.97 d (2.0)	74.4
2	2.27 dt (16.6, 2.9)	26.4	1.98 m	22.5	2.43 dt (16.6, 2.9)	26.9	5.45 ddd (13.1, 4.5, 2.0)	67.5
	2.15 dt (16.6, 2.9)		1.94 m		2.28 dt (16.6, 2.9)			
3	4.94 t (2.9)	77.2	1.81 m, 1.10 m	30.5	5.01 t (2.9)	76.7	2.23 m, 1.44 m	37.7
4		41.6		38.4		41.6		40.2
5		77.0		77.2		75.7		76.4
6	1.96 (2H) m	26.5	1.67 (2H) m	25.2	2.06 (2H) m	24.4	5.70 t (8.1)	72.5
7	1.73 (2H) m	23.7	1.69 (2H) m	25.7	2.81 m	23.3	3.32 dd (16.6, 8.1)	31.7
					2.77 m		2.86 dd (16.6, 9.0)	
8	1.84 m	34.4	2.06 m	34.7		125.4		126.5
9	2.91 td (11.1, 6.8)	32.4	2.59 td (11.4, 5.8)	37.3		142.9		137.7
10		43.8		43.6		46.5		51.1
11	2.39 dd (16.4, 11.1)	21.8	2.24 dd (16.0, 5.8)	21.7	6.28 s	102.1	7.10 s	104.2
	2.24 dd (16.4, 6.8)		2.45 m					
12		148.7		150.4		158.0		153.6
13		122.8		113.9		123.9		126.3
14	2.64 quintet (6.8)	31.4	3.27 d (9.6)	48.1		132.7		128.8
15	6.19 d (1.9)	109.6	6.14 d (1.9)	108.7	3.10 t (9.0)	29.2	6.72 d (2.2)	104.8
16	7.22 d (1.9)	140.6	7.23 d (1.9)	141.1	4.49 t (9.0)	70.8	7.54 d (2.2)	144.9
17	1.07 d (6.8)	17.4		174.5	2.13 s	16.4	2.36 s	16.0
18	1.10 s	23.2	1.09 s	21.1	1.18 s	23.1	1.39 s	30.6
19	1.14 s	25.5	1.02 s	25.1	1.17 s	25.1	1.26 s	25.5
20	1.10 s	17.9	1.14 s	17.3	1.35 s	30.9	1.52 s	29.9
OCO*CH$_3$*-1	2.05 s	21.2	2.10 s	21.5	1.94 s	21.1	1.97 s	21.1
O*C*OCH$_3$-1		169.3		169.0		169.5		169.5
OCO*CH$_3$*-2							2.05 s	21.1
O*C*OCH$_3$-2								170.5
OCO*CH$_3$*-3	2.06 s	21.4			2.00 s	21.4		
O*C*OCH$_3$-3		169.3				169.6		
OCO*CH$_3$*-6							2.20 s	21.8
O*C*OCH$_3$-6								170.6
OH-5	3.30 s		3.00 s		3.38 d (2.2)		3.04 br s	
O*CH$_3$*-17			3.76 s	51.9				

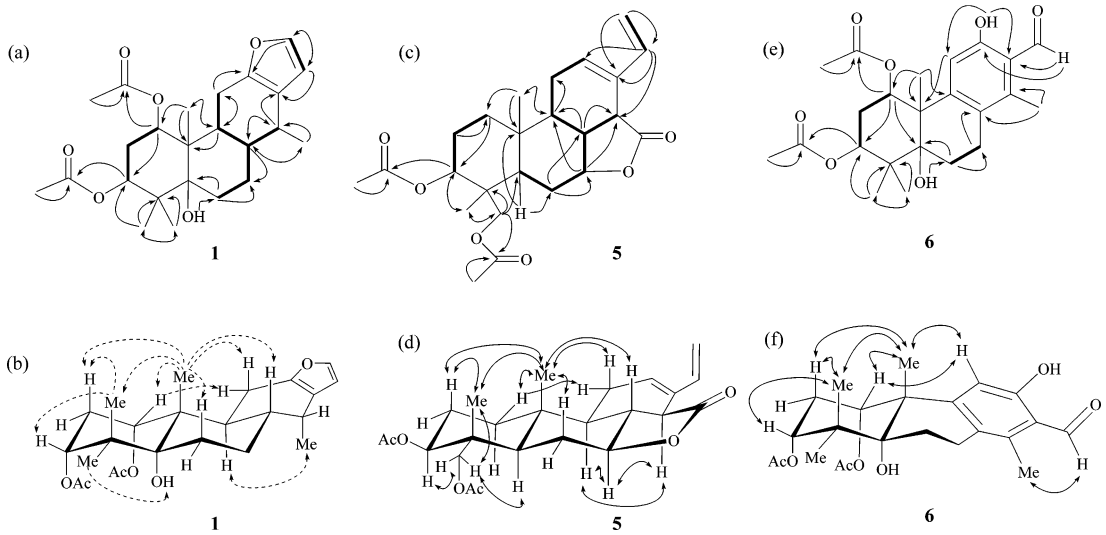

Figure 1. Connectivities (bold lines) deduced by the COSY spectrum and key HMBC correlations (arrow) (a, c, e) and selected NOE (dashed arrow) and ROESY (arrow) correlations (b, d, f) for **1**, **5**, and **6**.

169.3 (OCO-1) with the protons at δ 2.06 ($OCOCH_3$-3) and 4.94 (H-3).

The relative stereochemistry of **1** was determined on the basis of coupling constants and the results of difference NOE experiments (Figure 1b). The NOEs from H_3-20 to H-2$_{ax}$ (δ 2.27), H-8, H-11$_{ax}$ (δ 2.39), and H_3-19, from H_3-19 to H-2$_{ax}$ (δ 2.27), and from H_3-18 to OH-5 indicated that rings A and B have a chair conformation with *trans*-fused ring junctions. On the other hand, the small coupling constant between H-1 and H-2 (2.9 Hz) and between H-2 and H-3 (2.9 Hz) and NOEs from H_3-20 to H-1 and from H_3-19 to H-3 indicated the acetyl substituents at C-1 and C-3 to both be in the α-axial orientation. Similarly, the NOE from H_3-17 to H-9 suggested that the C-17 methyl is α-axial. From this spectroscopic evidence, the structure of caesalpinin MA was concluded to be **1**.

Caesalpinin MB (**2**) was isolated as a colorless amorphous solid with $[\alpha]_D^{25}$ +30.8° ($CHCl_3$), and its molecular formula was determined to be $C_{23}H_{32}O_6$ by HRFABMS. The IR absorptions at 3650 and 1735 cm^{-1} indicated the presence of hydroxyl and carbonyl groups, respectively. The ^{1}H and ^{13}C NMR spectral data of **2** were similar to those of 7-acetoxybonducellpin C (**9**)[11] except for the presence of one more acetyl group in **9**. The locations of the acetyl and carbomethoxy groups were concluded to be at C-1 and C-17 by the analysis of the COSY, HMQC, and HMBC spectra.

Table 2. ^{1}H NMR (400 MHz) and ^{13}C NMR (100 MHz) Data (δ) for Compounds **5**–**8** in $CDCl_3$ (*J* values in parentheses)

	5		**6**		**7**		**8**	
position	^{1}H	^{13}C	^{1}H	^{13}C	^{1}H	^{13}C	^{1}H	^{13}C
1	1.67 m, 1.27 m	35.7	5.61 t (3.2)	73.2	5.94 d (3.2)	73.3	4.91 t (3.2)	75.1
2	1.83 m	22.7	2.43 dt (16.6, 3.2)	26.8	5.66 t (3.2)	66.0	1.94 m	22.3
	1.67 m		2.32 dt (16.6, 3.0)				1.78 m	
3	4.75 dd (11.6, 4.3)	73.8	5.03 t (3.0)	77.0	5.24 d (3.2)	76.8	1.11 (2H) m	30.5
4		41.0		41.6		42.9		38.5
5	1.50 m	45.5		75.4		75.3		79.0
6	2.10 m, 1.64 m	25.6	2.10 (2H) m	24.3	2.04 m, 1.30 m	24.2	5.48 d (9.0)	74.6
7	3.91 dd (10.7, 4.3)	81.8	2.84 m, 2.71 dd	23.2	2.77 (2H) m	23.2	5.67 t (9.0)	71.3
8	1.89 m	46.6	(17.1, 6.8)	125.6		125.2	2.79 m	48.0
9	1.5 m	44.2		154.0		153.6	3.15 ddd (13.4,	38.4
10		37.4		47.2		48.9	11.2, 5.0)	44.8
11	2.17 (2H) m	24.4	6.50 s	111.0	6.50 s	111.0	2.74 m, 2.59 dd	23.5
12	5.78 q (3.4)	129.4		161.3		161.4	(16.8, 5.0)	164.6
13		133.0		117.1		117.2		120.1
14	2.90 br d (13.6)	43.8		140.1		140.2		191.9
15	6.43 dd (17.5, 11.2)	134.6	10.38 s	195.1	10.38 s	195.1	6.61 d (1.9)	106.6
16	5.42 d (17.5), 5.13 d (11.2)	115.1					7.31 d (1.9)	143.4
17		173.6	2.48 s	13.4	2.47 s	13.4		
18	3.86 d (11.9), 3.73 d (11.9)	65.0	1.18 s	21.1	1.19 s	22.8	1.14 s	30.5
19	0.94 s	14.0	1.18 s	25.1	1.25 s	25.0	1.16 s	24.7
20	1.00 s	14.8	1.36 s	29.7	1.47 s	29.9	1.34 s	17.3
OCO*CH$_3$*-1			1.95 s	21.1	2.08 s	20.9	2.10 s	21.6
O*C*OCH$_3$-1				169.3		169.9		169.4
OCO*CH$_3$*-2					2.02 s	20.8		
O*C*OCH$_3$-2						169.4		
OCO*CH$_3$*-3	2.07 s	20.9	2.01 s	21.2	1.98 s	20.7		
O*C*OCH$_3$-3		170.5		169.4		169.3		
OCO*CH$_3$*-6							2.09 s	21.4
O*C*OCH$_3$-6								170.6
OCO*CH$_3$*-7							2.01 s	21.6
O*C*OCH$_3$-7								170.0
OCO*CH$_3$*-18	2.04 s	21.1						
O*C*OCH$_3$-18		170.6						
OH-5			3.72 s		3.48 d (2.9)		2.73 br s	
OH-12			11.79 s		11.75 s			

The relative stereochemistry of **2** was determined on the basis of coupling constants and ROESY correlations. The small coupling constant between H-1 and H-2 (2.9 Hz) suggested that the acetyl substituent at C-1 was α-axially oriented, which was confirmed by the ROESY correlation between H_3-20 and H-1. Similarly, the configuration at C-14 was concluded to be β-COOMe from the ROESY correlation between H-14 and H-9 and the large coupling constant between H-14 and H-8 (9.6 Hz). Thus, the structure of caesalpinin MB was concluded to be **2**.

Caesalpinin MC (**3**) was also isolated as a colorless amorphous solid with $[\alpha]_D^{25}$ −38.9° ($CHCl_3$). The IR spectrum of **3** indicated the presence of hydroxyl and carbonyl groups, and HRFABMS showed the molecular formula $C_{24}H_{32}O_6$. The ^{1}H NMR spectrum of **3** displayed the signals of four tertiary methyls, three oxygen-substituted methines, two dihydrofuran methylenes, and two acetyl methyls (Table 1). The ^{13}C NMR spectrum of **3** exhibited 24 signals including two ester carbonyl carbons, six olefinic carbons, four oxygen-substituted carbons, and four aliphatic methylene carbons (Table 1). The presence of a dihydrofuran ring in **3** was deduced from the high-field shift of H_2-16 (δ 4.49) and H_2-15 (δ 3.10) in the ^{1}H NMR spectrum. Moreover, the low-field chemical shifts of H-11 (δ 6.28), H_3-17 (δ 2.13), C-8 (δ 125.4), C-9 (δ 142.9), C-11 (δ 102.0), and C-14 (δ 132.7) suggested that ring C in **3** is aromatic. The locations of the two acetyl substituents at C-1 and C-3 were confirmed by the analysis of the HMQC and HMBC spectra. The relative stereochemistry of **3** was determined from the coupling constants and ROESY correlations. The small coupling constants of H-1 and H-3 with H-2 (both 2.9 Hz) and the ROESY correlations between H_3-20 and H-1 and between H_3-19 and H-3 indicated the acetyl substituents at C-1 and C-3 to be α-axially oriented. Thus, caesalpinin MC was assigned with the structure **3**.

Caesalpinin MD (**4**) was isolated as a colorless amorphous solid with $[\alpha]_D^{25}$ +19.5° ($CHCl_3$). The IR absorptions at 3600 and 1730 cm^{-1} indicated the presence of hydroxyl and ester carbonyl groups, and its molecular formula was determined to be $C_{26}H_{32}O_8$ by HRFABMS. The ^{1}H and ^{13}C NMR spectral data were similar to those of 2-acetoxycaesaldekarin e (**10**), except for the position of one of the acetyl substituents. The location of the acetyl group was determined to be C-6 instead of C-3 in **10** by the analysis of the COSY, HMQC, and HMBC spectra. The relative stereochemistry of **4** was also determined to be the same as **10** from the coupling constants ($J_{1,2}$ = 2.0 Hz, $J_{6,7}$ = 8.1 Hz) and the ROESY correlations of H_3-20 with H-1 and H-6.

Caesalpinin ME (**5**) was isolated as a colorless amorphous solid with $[\alpha]_D^{25}$ +11.4° ($CHCl_3$). The IR absorptions at 1770 and 1730 cm^{-1} indicated the presence of γ-lactone and ester carbonyl groups, respectively, and its molecular formula was determined to be $C_{24}H_{32}O_6$ by HRFABMS. The ^{1}H NMR spectrum of **5** displayed signals due to two tertiary methyls, two oxygen-substituted methines, four aliphatic methines, an oxygen-substituted methylene, three oxygen-nonsubstituted methylenes, and four olefinic protons together with two acetyl methyls (Table 2). Moreover, the ^{13}C NMR spectrum displayed signals due to a lactone carbonyl carbon (δ 173.6), four olefinic carbons (δ 134.6, 133.0, 129.4, 115.1), two oxygen-substituted methines (δ 81.8, 73.8), four oxygen-nonsubstituted methines, an oxygen-substituted methylene (δ 65.0), three oxygen-nonsubstituted methylenes, two oxygen nonsubstituted quaternary carbons, and two tertiary methyls, together with those of

two acetyl groups (Table 2). These spectral data indicated the absence of a furan ring and a C-5 hydroxyl group and were similar to those of caesaldekarin L,[13] except for the presence of a γ-lactone ring between C-17 and C-7 in **5**. The presence of the lactone ring was confirmed by the analysis of the COSY, HMQC, and HMBC spectra and by the IR absorption at 1770 cm^{-1}. The location of a vinylic group was determined to be at C-13 on the basis of the HMBC correlations of the vinylic protons at δ 6.43 (H-15) with C-12, C-13, and C-14 and of the vinylic protons at δ 5.42 and 5.13 (H-16) with C-13. On the other hand, the locations of two acetoxyl substituents were determined to be at C-3 and C-18 by the HMBC correlations of the ester carbonyl carbon at δ 170.5 (OCO-3) with the protons at δ 2.04 ($OCOCH_3$-3) and 4.75 (H-3) and of the ester carbonyl carbon at δ 170.6 (OCO-18) with the protons at δ 2.08 ($OCOCH_3$-18), 3.86, and 3.73 (H_2-18) (Figure 1c). The relative stereochemistry of **5** was deduced by the analysis of the coupling constants and ROESY correlations. A large coupling constant between H-3 and H-2_{ax} (δ 1.83) (11.6 Hz) and the ROESY correlations of H-3 with H-5 and H-1_{ax} (δ 1.27) indicated H-3 to be α-axial, i.e., the acetyl substituent to be β-equatorial. Similarly, a large coupling constant between H-7 and H-8 (10.7 Hz) and the ROESY correlations between H_3-20 and H-8, between H-14 and H-9, and between H-7 and H-9 indicated H-7 and H-14 to be both α-axial (Figure 1d).

Norcaesalpinin MA (**6**) was isolated as a colorless amorphous solid with $[\alpha]_D^{25}$ −15° ($CHCl_3$), and its molecular formula was determined to be $C_{23}H_{30}O_7$ by HRFABMS. The IR spectrum of **6** indicated the presence of hydroxyl (3650 cm^{-1}), ester carbonyl (1735 cm^{-1}), and aldehyde (1630 cm^{-1}) functionalities. The ^1H NMR spectrum of **6** displayed signals for four tertiary methyls, two acetyl methyls, an aldehyde (δ 10.38), an olefinic proton (δ 6.50), two hydroxyl protons (δ 11.79, 3.72), and three methylenes (Table 2). The ^{13}C NMR spectrum of **6** showed the signals of an aldehyde carbon (δ 195.1), six olefinic carbons (δ 161.3, 154.0, 140.1, 125.6, 117.1, 111.0), three oxygen-substituted carbons (δ 77.0, 75.4, 73.2), and three methylene carbons together with two ester carbonyl carbons (δ 169.4, 169.3) (Table 2). Excluding the signals due to two acetyl substituents, **6** contained only 19 carbons in the main carbon framework, suggesting it to be a norditerpene. These ^1H and ^{13}C NMR data were similar to those of caesaldekarin e (**11**),[8] except for the presence of an aldehydic group instead of the 1,2-disubstituted furan ring in **11**. The location of the aldehyde group was determined to be at C-13 from the HMBC correlations of the aldehydic proton (δ 10.38) with three olefinic carbons at C-12, C-13, and C-14. Moreover, the hydroxyl proton at δ 11.79 showed HMBC correlations with C-11, C-12, and C-13, suggesting that the hydroxyl group should be located at C-12. On the other hand, the locations of two acetoxyl substituents were determined to be at C-1 and C-3 from the HMBC correlations of the ester carbonyl carbon at δ 169.3 (OCO-1) with the protons at δ 1.95 ($OCOCH_3$-1) and 5.61 (H-1) and of the ester carbonyl carbon at δ 169.4 (OCO-3) with the protons at δ 2.01 ($OCOCH_3$-3) and 5.03 (H-3) (Figure 1e). The relative stereochemistry of **6** was determined by analysis of coupling constants and ROESY correlations (Figure 1f). Thus, norcaesalpinin MA was concluded to be a 16-norcassane-type diterpene with the structure **6**.

Norcaesalpinin MB (**7**) was also isolated as a colorless amorphous solid having $[\alpha]_D^{25}$ −40.6° ($CHCl_3$). Its molecular formula was determined to be $C_{25}H_{32}O_9$ by HRFABMS. The IR spectrum indicated the presence of hydroxyl (3650 cm^{-1}), ester carbonyl (1735 cm^{-1}), and aldehyde (1630 cm^{-1}) functionalities. The ^1H and ^{13}C NMR spectra of **7** were similar to those of norcaesalpinin MA (**6**), except for the presence of one more acetoxyl substituent (Table 2). The location of the additional acetoxyl substituent was deduced to be at C-2 from low-field shifts of H-2 and C-2, which was confirmed by the HMBC correlations. The relative stereochemistry of **7** was determined to be the same as **3** and **6**. Thus, norcaesalpinin MB (**7**) was assigned as 2-*O*-acetylnorcaesalpinin MA.

Norcaesalpinin MC (**8**) was also isolated as a colorless amorphous solid having $[\alpha]_D^{25}$ +27.4° ($CHCl_3$). Its molecular formula was determined to be $C_{25}H_{32}O_9$ by HRFABMS. The IR absorptions at 3500 and 1730 cm^{-1} indicated the presence of hydroxyl and carbonyl groups, respectively. The ^1H NMR spectrum of **8** displayed signals of three tertiary methyls, three acetyl methyls, three methylenes, and three oxygen-substituted methines, together with two protons of a 1,2-disubstituted furan ring (δ 7.31, 6.61) (Table 2). The ^{13}C NMR spectrum of **8** showed the signals of a ketone carbonyl carbon (δ 191.9), four olefinic carbons, four oxygen-substituted carbons, and three methylene carbons together with three ester carbonyl carbons (δ 170.6, 170.0, 169.4). Excluding the signals due to three acetyl substituents, **8** contained only 19 carbons in the main carbon framework, suggesting it to be a norditerpene. The ^1H and ^{13}C NMR data of **8** were similar to those of caesalmin C (**12**), except for the presence of the signal of a ketone carbonyl carbon instead of the vinylic methylene in **12**. The HMBC correlations of two methine protons H-8 and H-9 with the ketone carbonyl carbon indicated that the ketone carbonyl carbon should be C-14; that is, **8** is a 17-norcassane-type diterpene. The relative stereochemistry of **8** was determined from the coupling constants and ROESY correlations, which were similar to those of **12**. Thus, the structure of norcaesalpinin MC was assigned as **8**.

In conclusion, we have reported herein eight new diterpenes, caesalpinins MA−ME (**1**−**5**) and norcaesalpinins MA−MC (**6**−**8**). Among them, **1**−**4** are cassane-type furanoditerpenes, and **5** represents a cassane-type diterpene without the C-5 hydroxyl substituent and the furan ring, which are the main characteristic features of diterpenes from plant in the genus *Caesalpinia*. On the other hand, caesalpinin MC (**3**) represents the first example of a cassane-type furanoditerpene having a dihydrofuran ring. Among the norcaesalpinins isolated, norcaesalpinins MA (**6**) and MB (**7**) are 16-norcassane-type diterpenes, while norcaesalpinin MC (**8**) is a 17-norcassane-type diterpene.

Experimental Section

General Experimental Procedures. Optical rotations were recorded on a JASCO DIP-140 digital polarimeter. IR spectra were measured with a Shimadzu IR-408 spectrophotometer in $CHCl_3$ solution. NMR spectra were taken on a JEOL JNM-LA400 spectrometer with tetramethylsilane (TMS) as an internal standard, and chemical shifts are expressed as δ values. HRFABMS measurements were carried out on a JEOL JMS-700T spectrometer, and glycerol was used as matrix. Column chromatography was performed with BW-820MH silica gel (Fuji Silysia, Aichi, Japan). Analytical and preparative TLC were carried out on precoated silica gel $60F_{254}$ and RP-$18F_{254}$ plates (Merck, 0.25 or 0.50 mm thickness).

Plant Materials. Seed kernels of *Caesalpinia crista* L. were purchased from Theingyi Market, Yangon City, Myanmar, in April 2003. A voucher specimen (TMPW 22188) is preserved in the Museum of Matria Medica, Analytical Research Center for Ethnomedicines, Institute of Natural Medicine, Toyama Medical and Pharmaceutical University, Toyama, Japan.

Extraction and Isolation. The powdered air-dried seed kernels of *C. crista* (780 g) were extracted with CH_2Cl_2 (3 L × 3) at room temperature, overnight. The CH_2Cl_2 extract (130 g) was fractionated by silica gel column chromatography (7 × 45 cm) with a benzene/EtOAc gradient system to give seven fractions. Fraction 1 (115 g) was a mixture of fatty substances, as indicated by the ^{1}H NMR spectrum.

Fraction 2 (1.2 g) was rechromatographed on a silica gel column (25 × 1.2 cm) with 5% acetone/hexane to afford four subfractions. Subfraction 2-2 (110 mg) was further subjected to reversed-phase preparative TLC with MeOH/CH_3CN/H_2O (2:1:1) to give caesalpinin MA (**1**, 3.2 mg), 14(17)-dehydrocaesalmin F (20.0 mg),[7] caesaldekarin e (25.0 mg),[8] and caesalpinin C (4.5 mg).[4] Subfraction 2-3 (50 mg) was also separated by reversed-phase preparative TLC with MeOH/CH_3CN/H_2O (2:1:1) to give caesalpinin MB (**2**, 0.8 mg), caesaldekarin e (2.5 mg), and caesalmin B (2.5 mg).[9] Subfraction 2-4 (525 mg) was subjected to normal-phase preparative TLC with 1% MeOH/$CHCl_3$ to give caesalpinin MC (**3**, 2.2 mg), norcaesalpinin MA (**6**, 1.6 mg), caesalmin C (12.0 mg),[5] caesalmin E (4.0 mg),[5] 2-acetoxy-3-deacetoxycaesaldekarin e (2.0 mg),[10] and 2-acetoxycaesaldekarin e (2.0 mg).[7]

Fraction 3 (1.5 g) was rechromatographed on a silica gel column (18 × 2.5 cm) with 5% acetone/hexane to afford five subfractions. Subfraction 3-1 (750 mg) gave a solid, which was washed with hexane several times to afford 14(17)-dehydrocaesalmin F (450 mg). The hexane-soluble oily substance was subjected to normal-phase preparative TLC with 0.5% MeOH/$CHCl_3$ to give norcaesalpinin B (2.3 mg).[3] Similarly, subfraction 3-2 (40 mg) was subjected to normal-phase preparative TLC with 1% acetone/$CHCl_3$ to give 7-acetoxybonducellpin C (3.0 mg)[11] and caesalpinin E (8.0 mg).[4] Subfraction 3-3 (150 mg) was also separated by normal-phase preparative TLC with 2% MeOH/$CHCl_3$ to give caesalpinin MD (**4**, 3.1 mg), norcaesalpinin MC (**8**, 4.0 mg), and 2-acetoxycaesaldekarin e (50.0 mg).[7] Subfraction 3-4 (60 mg) was further subjected to reversed-phase preparative TLC with MeOH/CH_3CN/H_2O (2:1:1) to afford caesalpinin ME (**5**, 5.1 mg), caesaldekarin e (5.3 mg), and caesalmin C (14.0 mg).[5] Subfraction 3-5 (50 mg) was then separated by normal-phase preparative TLC with 1% MeOH/$CHCl_3$ to give norcaesalpinin MB (**7**, 1.5 mg), 2-acetoxycaesaldekarin e (12.0 mg),[7] and 6-acetoxy-3-deacetoxycaesaldekarin e (5.0 mg).[12]

Caesalpinin MA (1): colorless amorphous solid; $[\alpha]_D^{25}$ −12.6° (*c* 0.2, $CHCl_3$); IR ($CHCl_3$) ν_{max} 3650, 1730 cm^{-1}; ^{1}H and ^{13}C NMR, see Table 1; HRFABMS *m/z* 419.2456 [calcd for $C_{24}H_{35}O_6$ (M + H)$^+$ 419.2434].

Caesalpinin MB (2): colorless amorphous solid; $[\alpha]_D^{25}$ +30.8° (*c* 0.08, $CHCl_3$); IR ($CHCl_3$) ν_{max} 3650, 1735 cm^{-1}; ^{1}H and ^{13}C NMR, see Table 1; HRFABMS *m/z* 405.2275 [calcd for $C_{23}H_{33}O_6$ (M + H)$^+$, 405.2277].

Caesalpinin MC (3): colorless amorphous solid; $[\alpha]_D^{25}$ −38.9° (*c* 0.1, $CHCl_3$); IR ($CHCl_3$) ν_{max} 3650, 1735 cm^{-1}; ^{1}H and ^{13}C NMR, see Table 1; HRFABMS *m/z* 417.2315 [calcd for $C_{24}H_{33}O_6$ (M + H)$^+$, 417.2277].

Caesalpinin MD (4): colorless amorphous solid; $[\alpha]_D^{25}$ +19.5° (*c* 0.1, $CHCl_3$); IR ($CHCl_3$) ν_{max} 3600, 1730 cm^{-1}; ^{1}H and ^{13}C NMR, see Table 1; HRFABMS *m/z* 473.2164 [calcd for $C_{26}H_{33}O_8$ (M + H)$^+$, 473.2175].

Caesalpinin ME (5): colorless amorphous solid; $[\alpha]_D^{25}$ +11.4° (*c* 0.2, $CHCl_3$); IR ($CHCl_3$) ν_{max} 1770, 1730 cm^{-1}; ^{1}H and ^{13}C NMR, see Table 2; HRFABMS *m/z* 417.2266 [calcd for $C_{24}H_{33}O_6$ (M + H)$^+$, 417.2277].

Norcaesalpinin MA (6): colorless amorphous solid; $[\alpha]_D^{25}$ −15.7° (*c* 0.13 $CHCl_3$); IR ($CHCl_3$) ν_{max} 3650, 1735, 1630 cm^{-1}; ^{1}H and ^{13}C NMR, see Table 2; HRFABMS *m/z* 419.2060 [calcd for $C_{23}H_{31}O_7$ (M + H)$^+$, 419.2070].

Norcaesalpinin MB (7): colorless amorphous solid; $[\alpha]_D^{25}$ −40.6° (*c* 0.07, $CHCl_3$); IR ($CHCl_3$) ν_{max} 3650, 1735, 1635 cm^{-1}; ^{1}H and ^{13}C NMR, see Table 2; HRFABMS *m/z* 477.2127 [calcd for $C_{25}H_{33}O_9$ (M + H)$^+$, 477.2125].

Norcaesalpinin MC (8): colorless amorphous solid; $[\alpha]_D^{23}$ +27.4° (*c* 0.2, $CHCl_3$); IR ($CHCl_3$) ν_{max} 3500, 1730 cm^{-1}; ^{1}H and ^{13}C NMR, see Table 2; HRFABMS *m/z* 477.2124 [calcd for $C_{25}H_{33}O_9$ (M + H)$^+$, 477.2125].

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References and Notes

(1) Ministry of Science and Technology, Yangon, Myanmar. *The Effective Myanmar Traditional Medicinal Plants*; 2001; Vol. 1, pp 67−78.
(2) *Medicinal Herb Index in Indonesia*, 1st ed.; PT Eisai Indonesia: Jakarta, 1986; p 140.
(3) Banskota, A. H.; Attamimi, F.; Usia, T.; Linn, T. Z.; Tezuka, Y.; Kalauni, S. K.; Kadota, S. *Tetrahedron Lett.* **2003**, *44*, 6879−6882.
(4) Linn, T. Z.; Awale, S.; Tezuka, Y.; Banskota, A. H.; Kalauni, S. K.; Attamimi, F.; Ueda, J.-Y.; Kadota, S. *J. Nat. Prod*., submitted.
(5) Jiang, R.-W.; Ma, S.-C.; But, P. P.-H.; Mak, T. C. W. *J. Nat. Prod.* **2001**, *64*, 1266−1272.
(6) Patil, A. D.; Freyer, A. J.; Webb, R. L.; Zuber, G.; Reichwein, R.; Bean, M. F.; Faucette, L.; Johnson, R. K. *Tetrahedron* **1997**, *53*, 1583−1592.
(7) Pascoe, K. O.; Burke, B. A.; Chan, W. R. *J. Nat. Prod.* **1986**, *49*, 913−915.
(8) Kitagawa, I.; Simanjuntak, P.; Mahmud, T.; Kobayashi, M.; Fujii, S.; Uji, T.; Shibuya, H. *Chem. Pharm. Bull.* **1996**, *44*, 1157−1161.
(9) Jiang, R.-W.; But, P. P.-H.; Ma, S.-C.; Mak, T. C. W. *Phytochemistry* **2001**, *57*, 517−521.
(10) Balmain, A.; Bjamer, K.; Connolly, J. D.; Ferguson, G. *Tetrahedron Lett.* **1967**, *49*, 5027−5031.
(11) Peter, S. R.; Tinto, W. F.; Mclean, S.; Reynolds, W. F.; Yu, M. *J. Nat. Prod*. **1997**, *60*, 1219−1221.
(12) Balmain, A.; Connolly, J. D.; Ferrari, M.; Ghisalberti, E. L.; Pagnoni, U. M.; Pelizzoni, F. *Chem. Commun.* **1970**, 1244−1245.
(13) Lyder, D. L.; Peter, S. R.; Tinto, W. F.; Bissada, S. M.; Mclean, S.; Reynolds, W. F. *J. Nat. Prod*. **1998**, *61*, 1462−1465.

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