Two Novel *abeo*-Dammaranes with a Six-Membered Acetal Moiety from *Aglaia perviridis* Hiern

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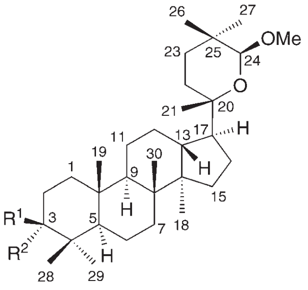
Two novel triterpenoids, named (20*S*,24*S*)-20,24-epoxy-24-methoxy-23(24→25)*abeo*-dammaran-3-one (=(20*S*,25*S*)-20,25-epoxy-25-methoxy-24,24-dimethyl-26,27-dinordammaran-3-one; **1**), (3*α*,20*S*,24*S*)-20,24-epoxy-24-methoxy-23(24→25)*abeo*-dammaran-3-ol-acetate (=(3*α*,20*S*,25*S*)-20,25-epoxy-25-methoxy-24,24-dimethyl-26,27-dinordammaran-3-ol acetate; **2**), together with six known dammaranes, were isolated from the EtOH extract of the twigs of *Aglaia perviridis* by chromatographic methods. The structures of **1** and **2** were elucidated on the basis of spectral data.

Introduction. – The genus *Aglaia* of the family Meliaceae has attracted considerable interest as a possible new source of unique natural products for integrated pest management. In the past decades, many novel compounds such as bis-amides, lignans, and triterpenes have been isolated from this genus [1]. Nevertheless, as a part of our work, we continued our search for novel constituents in the genus *Aglaia* [2–4]. The $CHCl_3$-soluble material of an EtOH extract of the twigs of *Aglaia perviridis* Hiern, which mainly distributed in South China and India [5], gave two *abeo*-dammaranes with a novel six-membered cyclic acetal moiety, (20*S*,24*S*)-20,24-epoxy-24-methoxy-23(24→25)*abeo*-dammaran-3-one (**1**), and (3*α*,20*S*,24*S*)-20,24-epoxy-24-methoxy-23(24→25)*abeo*-dammaran-3-ol acetate (**2**). The six known dammaranes cabraleone (=(24*S*)-20,24-epoxy-25-hydroxydammaran-3-one) [6], cabraleadiol (=(3*α*,24*S*)-20,24-epoxydammarane-3,25-diol) [7], cabraleadiol 3-acetate (=(3*α*,24*S*)-20,24-epoxydammarane-3,25-diol 3-acetate) [8], cabralealactone (=(5*α*)-20-hydroxy-4,4,8,14-tetramethyl-3-oxo-18-norcholan-24-oic acid γ-lactone) [9], cabraleahydroxylactone (=(3*α*,5*α*)-3,20-dihydroxy-4,4,8,14-tetramethyl-18-norcholan-24-oic acid *γ*-lactone) [10], and cabraleahydroxylactone 3-acetate (=(3*α*,5*α*)-3-(acetyloxy)-20-hydroxy-4,4,8,14-tetramethyl-18-norcholan-24-oic acid *γ*-lactone) [11], were also isolated from the same extract. According to our knowledge, this is the first report of the chemical constituents from *A. perviridis.*

The molecular skeleton of a 23(24→25)*abeo*-dammarane is rarely encountered in nature. Although a 23(24→25)*abeo*-dammarane with an acyclic side chain at C(17), (20*R*)-23(24→25)*abeo*-20,24-dihydroxydammaran-3-one (=(20*R*)-20,25-dihydroxy-24,24-dimethyl-26,27-dinordammaran-3-one), has been reported [12], no cyclic-acetal side chain resulting from a 23(24→25) rearrangement of the dammarane skeleton has



1 R^1, R^2 = O
2 R^1 = H, R^2 = OAc

been published. In this paper, we describe the isolation of **1** and **2** and the elucidation of their structures by means of 1D and 2D NMR data and mass spectra.

Results and Discussion. – Compound **1**, a white powder, was found to possess a molecular formula $C_{31}H_{52}O_3$ as evidenced by HR-ESI-MS (*m/z* 495.3832 ([*M* + Na]$^+$)), corresponding to six degrees of unsaturation. The IR spectrum showed the presence of a carbonyl group (1701 cm^{-1}). By analysis of the 1D and 2D NMR and MS data, as well as by comparison with the NMR data of known dammaranes [6–13], **1** was established to be (20*S*,24*S*)-20,24-epoxy-24-methoxy-23(24 → 25)*abeo*-dammaran-3-one.

The ^{13}C-NMR (DEPT) spectrum of **1** (*Table*) displayed signals for 31 C-atoms, nine tertiary Me groups (δ 15.1, 16.0, 16.4, 20.3, 21.0, 24.0, 25.9, 26.6, and 56.4), ten CH_2 groups (δ 19.6, 22.0, 24.0, 27.2, 30.9, 31.1, 32.2, 34.5, 34.1, and 39.9), five CH groups (δ 42.9, 44.2, 49.9, 55.3, and 104.2), and seven quaternary C-atoms (δ 33.3, 36.8, 40.2, 47.4, 50.5, 77.9, and 218.1). These spectral data were quite similar to those of cabraleone [6], cabralealactone [9], and (20*R*)-23(24 → 25)*abeo*-20,24-dihydroxy dammaran-9-one [12] except for the resonances attributable to the side chain [8][12][13]. Hence, **1** was expected to be a dammarane with a C=O group at C(3). This assumption was confirmed by the HMBC experiment (*Fig.*). Thus four rings were now accounted for, and therefore, C(17) of **1** carried an alicyclic side chain in consideration of the six degrees of unsaturation. In the HMBC plot, the cross-peak between the acetal proton H–C(24) (δ(H) 4.11 (*s*)) and the oxygenated quaternary C(20) (δ 77.9) indicated that there was an epoxy moiety between the acetal C-atom and the oxygenated quaternary C-atom, and the cross-peak between the MeO group (δ(H) 3.38 (*s*)) and C(24) (δ 104.2) placed the MeO group at C(24). The correlations between H–C(24) and C(23), C(25), C(26), and C(27) (δ 32.2, 33.3, 25.9, and 20.3, resp.) suggested that a $Me_2C(25)-CH_2(23)$ moiety was connected to C(24). Furthermore, the cross-peaks of Me(21) (δ(H) 1.17 (*s*)), $CH_2(22)$ (δ(H) 1.52–1.57 (*m*)), and H–C(17) (δ(H) 2.13–2.20 (*m*)) with C(20) were observed in the HMBC (*Fig.*). Thus, the side chain of **1** was determined as an epoxy-substituted 2,2,5-trimethyl-1-methoxypentane moiety. The configuration (*S*) was assigned to C(20), which is the configuration of most of dammarane triterpenes, particularly of those isolated from the *Aglaia* genus [7]. This was further supported by the correlations of H–C(13) (δ(H) 1.54–1.64 (*m*)) with Me(21), and of H–C(17) with H–C(24) in the ROESY plot [14]. The NOEs between H–C(24) and H–C(17) showed their *cis*-configuration, and the NOEs between Me(21) and MeO–C(24) (δ(H) 3.38 (*s*)) and Me(26) (δ(H) (0.91 (*s*)) indicated that the MeO group was in a 'β'-equatorial configuration (*Fig.*).

Compound **2**, obtained as a white powder, had the molecular formula $C_{33}H_{56}O_4$, as evidenced by HR-ESI-MS (*m/z* 539.4102 ([*M* + Na]$^+$)). According to its ^{1}H- and ^{13}C-NMR spectra (*Table*), assigned by means of HMQC and HMBC experiments, and

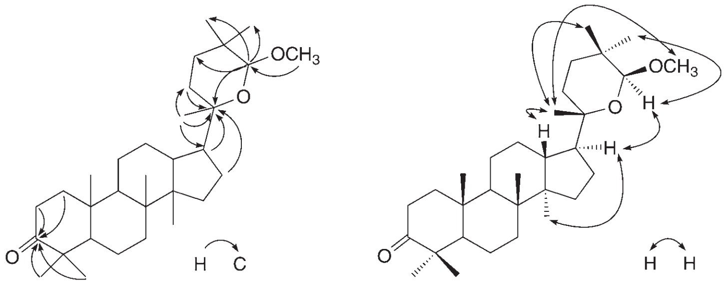


Figure. *Key HMBC* (H → C) *and ROSEY* (H ↔ H) *correlations of* **1**

Table. *^{13}C- and ^{1}H- NMR Data* (400 and 125 MHz, resp.; $CDCl_3$) *of* **1** *and* **2**. δ in ppm, *J* in Hz.

	δ(C)		δ(H)	
	1	**2**	**1**	**2**
$CH_2(1)$	39.9 (*t*)	34.2 (*t*)	1.88 – 1.95, 1.42 – 1.46 (2*m*)	1.40 – 1.48, 1.15 – 1.19 (2*m*)
$CH_2(2)$	34.1 (*t*)	22.8 (*t*)	2.39 – 2.55 (*m*)	1.86 – 1.94, 1.54 – 1.61 (2*m*)
C(3) or H–C(3)	218.1 (*s*)	78.3 (*d*)	–	4.62 (*t*, *J* = 2.9)
C(4)	47.4 (*s*)	37.1 (*s*)	–	–
H–C(5)	55.3 (*d*)	50.7 (*d*)	1.37 – 1.40 (*m*)	1.40 – 1.44 (*m*)
$CH_2(6)$	19.6 (*t*)	18.0 (*t*)	1.46 – 1.50 (*m*)	1.40 – 1.43 (*m*)
$CH_2(7)$	34.5 (*t*)	35.0 (*t*)	1.57 – 1.60, 1.32 – 1.36 (2*m*)	1.54 – 1.61, 1.26 – 1.30 (2*m*)
C(8)	40.2 (*s*)	40.5 (*s*)	–	–
H–C(9)	49.9 (*d*)	50.3 (*d*)	1.40 – 1.45 (*m*)	1.20 – 1.24 (*m*)
C(10)	36.8 (*s*)	36.7 (*s*)	–	–
$CH_2(11)$	22.0 (*t*)	21.3 (*t*)	1.48 – 1.53 (*m*)	1.46 – 1.53 (*m*)
$CH_2(12)$	24.0 (*t*)	24.0 (*t*)	1.68 – 1.76 (*m*)	1.69 – 1.77 (*m*)
H–C(13)	42.9 (*d*)	42.6 (*d*)	1.54 – 1.64 (*m*)	1.54 – 1.62 (*m*)
C(14)	50.5 (*s*)	50.6 (*s*)	–	–
$CH_2(15)$	31.1 (*t*)	31.2 (*t*)	1.47 – 1.51, 1.08 – 1.13 (2*m*)	1.46 – 1.50, 1.07 – 1.12 (2*m*)
$CH_2(16)$	27.2 (*t*)	27.2 (*t*)	1.52 – 1.56 (*m*)	1.70 – 1.75 (*m*)
H–C(17)	44.2 (*d*)	43.8 (*d*)	2.13 – 2.20 (*m*)	2.12 – 2.18 (*m*)
Me(18)	16.4 (*q*)	16.8 (*q*)	0.91 (*s*)	0.94 (*s*)
Me(19)	16.0 (*q*)	16.0 (*q*)	0.93 (*s*)	0.86 (*s*)
C(20)	77.9 (*s*)	78.0 (*s*)	–	–
Me(21)	24.0 (*q*)	24.0 (*q*)	1.17 (*s*)	1.17 (*s*)
$CH_2(22)$	30.9 (*t*)	30.9 (*t*)	1.52 – 1.57 (*m*)	1.50 – 1.55 (*m*)
$CH_2(23)$	32.2 (*t*)	32.3 (*t*)	1.41 – 1.47 (*m*)	1.42 – 1.49 (*m*)
H–C(24)	104.2 (*d*)	104.2 (*d*)	4.11 (*s*)	4.11 (*s*)
C(25)	33.3 (*s*)	33.3 (*s*)	–	–
Me(26)	25.9 (*q*)	25.9 (*q*)	0.91 (*s*)	0.91 (*s*)
Me(27)	20.3 (*q*)	20.2 (*q*)	0.90 (*s*)	0.90 (*s*)
Me(28)	26.6 (*q*)	27.8 (*q*)	1.08 (*s*)	0.83 (*s*)
Me(29)	21.0 (*q*)	21.7 (*q*)	1.02 (*s*)	0.88 (*s*)
Me(30)	15.1 (*q*)	15.4 (*q*)	0.98 (*s*)	0.98 (*s*)
MeO	56.4 (*q*)	56.4 (*q*)	3.38 (*s*)	3.38 (*s*)
*Me*COO		21.4 (*q*)		2.09 (*s*)
Me*C*OO		170.8 (*s*)		

by comparison of the spectral data with those of **1**, the structure of **2** was established as (3α,20*S*,24*S*)-20,24-epoxy-24-methoxy-23(24 → 25)*abeo*-dammaran-3-ol acetate.

The ^{13}C-NMR spectrum of **2** showed 33 signals: ten Me, ten CH_2, and six CH groups, and seven quaternary C-atoms (*Table*). In comparison with the ^{13}C-NMR spectrum of **1**, that of **2** showed two additional C-signals (δ 170.8 (*s*) and 21.4 (*q*)) due to an acetyloxy group. Furthermore, a signal at δ 78.3(*d*) for the AcO-bearing C-atom instead of the C(3)=O signal (δ 218.1(*s*)) was observed in **2**. This was confirmed by an HMBC experiment, which showed cross-peaks between *Me*COO (δ(H) 2.09 (*s*)) and Me*C*OO (δ 170.8 (*s*)), and between H−C(3) (δ(H) 4.62 (*t*, $J = 2.9$ Hz) and Me*C*OO, C(2), C(3), C(4), and C(5) (δ 170.8 (*s*), 22.8 (*t*), 78.3 (*d*), 37.1 (*s*), and 50.7 (*d*), resp.). The configuration at C(3) was deduced to be α from the *J* value (δ(H) 4.62 (*t*, $J = 2.9$ Hz, H−C(3)). The configuration of C(20) and C(24) of **2** was attributed in a similar manner to that of **1**.

The triterpenoids **1** and **2** are dammaranes which underwent a side-chain rearrangement similar to that leading to (20*R*)-23(24 → 25)*abeo*-20,24-dihydroxydammaran-3-one by reduction of a postulated intermediate with a C(24) aldehyde group [12]. Also, the CH(24)=O group of this intermediate might undergo a condensation reaction with OH−C(20) followed by *O*-methylation of the formed hemiacetal to afford **1**.

Together with **1** and **2**, the six known dammaranes cabraleone [6], cabraleadiol [7], cabraleadiol 3-acetate [8], cabralealactone [9], cabraleahydroxylactone [10], and cabraleahydroxylactone 3-acetate [11] were isolated from the same extract. Their structures were elucidated by spectral data and comparison with literature values.

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Experimental Part

General. Column chromatography (CC) and TLC: silica gel (200–300 mesh) and silica gel *GF*$_{254}$ plates, resp., from *Qingdao Marine Chemical Factory* (China). Optical rotations: *DIP* digital polarimeter. IR Spectra: *Nicolet 750* instrument; KBr pellets; in cm^{-1}. NMR Spectra: *Bruker AM-400* spectrometer; δ in ppm rel. to Me_4Si as internal standard, *J* in Hz. MS: *MAT-95* (EI), *LCQ-Deca* (ESI), and *Apex* mass spectrometer (HR-ESI); in *m*/*z* (rel. %).

Plant Material. The twigs of *A. perviridis* were collected in Xishuangbanna County, Yunnan Province, China, in July 2006. The plants were identified by Prof. *Jing-Yun Cui*, Xishuangbanna Tropical Botanical Garden, Academica Sinica, China.

Extracion and Isolation. The air-dried twigs of *A. perviridis* (46 kg) were crushed and extracted with 95% EtOH/H_2O at reflux temp. to yield an EtOH extract. After evaporation of the EtOH, the viscous concentrate was partitioned between H_2O and petroleum ether, $CHCl_3$, and BuOH, resp. The $CHCl_3$ extract (151 g) was subjected to CC (SiO_2, $CHCl_3$/Me_2CO 1:0 → 1:1): *Fractions 1–13* (TLC monitoring). *Fr. 3* (9 g) was subjected to CC (SiO_2, petroleum ether/AcOEt 9:1 → 2:1): *Fr. 3.1–3.9. Fr. 3.2*, *3.3*, *3.8*, and *3.7* were purified by recrystallization in acetone: **2** (16 mg) from *Fr. 3.2*, **1** (17 mg) from *Fr. 3.3*, cabraleahydroxylactone 3-acetate (150 mg) from *Fr. 3.8*, and cabraleone (376 mg) from *Fr. 3.7. Fr. 3.6* and *3.9* were subjected to CC (SiO_2, $CHCl_3$/acetone 100:1, and petroleum ether/AcOEt 5:1, resp.): cabraleadiol 3-acetate (405 mg) from *Fr. 3.6*, and cabralealactone (65 mg) from *Fr. 3.9. Fr. 4* (10.5 g) and *Fr. 5* (6.2 g) were subjected to CC (SiO_2, petroleum ether/AcOEt 9:1 → 1:1 and 8:2 → 1:1, resp.), and the crude compounds were purified by recrystallization in acetone: cabraleahydroxylactone (727 mg) from *Fr. 4* and cabraleadiol (161 mg) from *Fr. 5*.

*(20*S*,24*S*)-20,24-Epoxy-24-methoxy-23(24 → 25)*abeo*-dammaran-3-one* (= *(20*S*,25*S*)-20,25-Epoxy-25-methoxy-24,24-dimethyl-26,27-dinordammaran-3-one*; **1**): White powder. $[\alpha]_D^{25} = +100$ ($c = 0.195$,

$CHCl_3$). IR (KBr): 2947, 2862, 1701, 1451, 1381, 1105, 1041, 962. ^{1}H- and ^{13}C-NMR: *Table.* EI-MS: 457 (6), 412 (15), 313 (10), 245 (40), 205 (34), 157 (100), 125 (63), 107 (45), 95 (54), 81 (51), 55 (38). ESI-MS: 495 ($[M+Na]^+$), 473 ($[M+H]^+$), 441 ($[M-MeO]^+$). HR-ESI-MS: 495.3832 ($[M+Na]^+$, $C_{31}H_{52}NaO_3^+$; calc. 495.3814).

*(3α,20*S*,24*S*)-20,24-Epoxy-24-methoxy-23(24 → 25)*abeo*-dammaran-3-ol Acetate* (*=(3α,20*S*,25*S*)-20,25-Epoxy-25-methoxy-24,24-dimethyl-26,27-dinordammaran-3-ol Acetate*; **2**): White powder. $[\alpha]_D^{25} = +29$ ($c = 0.075$, $CHCl_3$). IR (KBr): 2945, 2856, 1737, 1458, 1373, 1244, 1045, 1020. ^{1}H- and ^{13}C-NMR: *Table.* ESI-MS: 539 ($[M+Na]^+$), 485 ($[M-MeO]^+$). HR-ESI-MS: 539.4102 ($[M+Na]^+$, $C_{33}H_{56}NaO_4^+$; calc. 539.4076).

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