Diterpenes and Diterpene Glucosides from *Phlogacanthus curviflorus*

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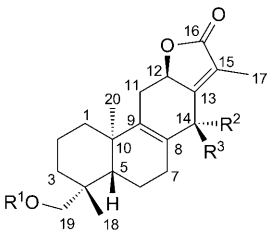
The four new diterpene and diterpene glucosides **1**–**4**, the new bergamotene derivative **5**, and the two new iridoid monoterpenoid glucosides **6** and **7**, together with the eleven known compounds **8**–**18**, were isolated from the EtOH extract of the roots of *Phlogacanthus curviflorus*. On the basis of chemical and spectroscopic evidence, their structures were identified as (4α,5β,10α,14α)-14,19-dihydroxyabieta-8,13(15)-dieno-16,12-lactone 19-(β-D-glucopyranoside) (=curvifloruside A; **1**), (4α,5β,10α,14α)-14,19-dihydroxyabieta-8,13(15)-dieno-16,12-lactone 19-[2-*O*-(4-hydroxy-3,5-dimethoxybenzoyl)-β-D-glucopyranoside] (=curvifloruside B; **2**), (4α,5β,10α)-19-hydroxy-14-oxoabieta-8,13(15)-dieno-16,12-lactone 19-[2-*O*-(4-hydroxy-3,5-dimethoxybenzoyl)-β-D-glucopyranoside] (=curvifloruside C; **3**), 19-hydroxy-jolkinolide E (**4**), 9-oxo-α-bergamoten-1-yl β-D-glucopyranoside (=curvifloruside D; **5**), 6-deoxyharpagoside (=curvifloruside E; **6**), and 6-epiharpagoside (=curvifloruside F; **7**). This is the first report on sesquiterpene and iridoid glycosides from the *Phlogacanthus* genus.

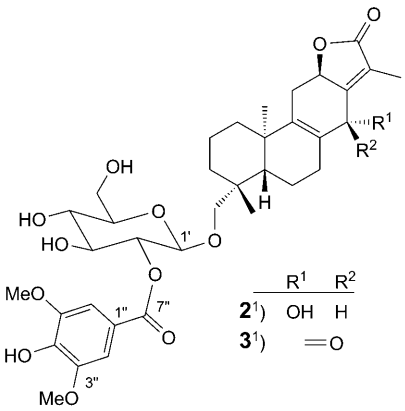
Introduction. – The genus *Phlogacanthus* of the Acanthaceae comprises about 30 species in the world and is mainly distributed in India and Malaysia. There are 4 species, including *P. curviflorus*, in China [1]. *Phlogacanthus curviflorus* (WALL) NEES is a shrub distributed in Yunnan Province of China as well as in Vietnam and India [2]. Its roots are used for the treatment of malaria [3]. A number of chemical constituents has been isolated from some species of *Phlogacanthus*, *e.g.*, diterpene lactones and their glucosides, steroids, and triterpenes [4–8]. Recently, two diterpenes and three diterpene glucosides have been isolated from the roots of *P. curviflorus* [9]. However, these references only reported on the diterpenes and their derivatives from several species, but there exists no report on biological studies of these compounds. In this study, four new diterpene and diterpene glucosides, one new bergamotene-derived glucoside, and two new iridoid monoterpenoid glucosides, together with eleven known compounds, were isolated from the EtOH extract of the roots of *P. curviflorus*. Their structures were identified on the basis of chemical and spectroscopic evidences. This is the first report on sesquiterpene and iridoid glycosides from the *Phlogacanthus* genus.

Results and Discussion. – After repeated column chromatographic purification on silica gel, the EtOH extract of the aerial part of *P. curviflorus* afforded the seven new compounds **1**–**7**[1]) and eleven known compounds, *i.e.*, **8**–**18**[1]).

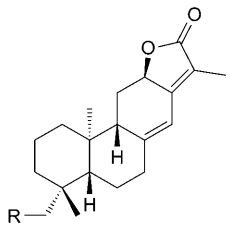
[1]) Trivial or arbitrary atom numberings; for systematic names, see *Exper. Part.*



	R^1	R^2	R^3
1[1])	Glc	OH	H
8[1])	H	OH	H
9[1])	Ac	AcO	H
10[1])	Glc	=O	



	R^1	R^2
2[1])	OH	H
3[1])	=O	



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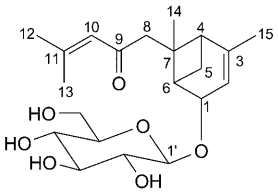
11 R = H



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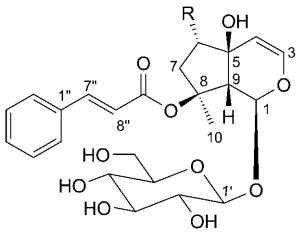

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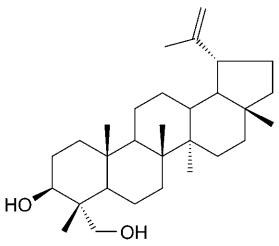
7[1]) R = OH



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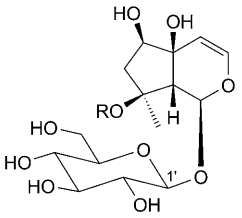

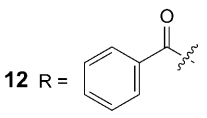

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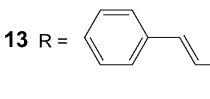

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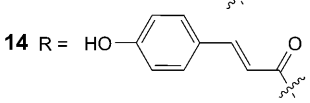

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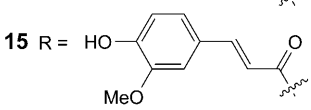

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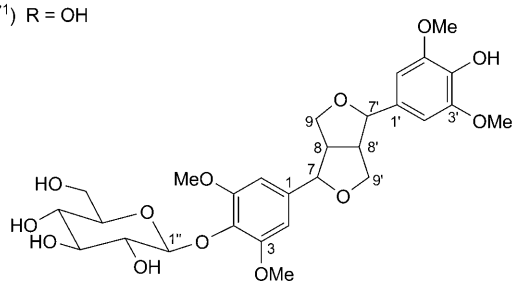

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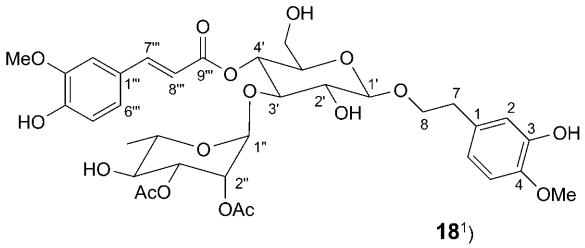


18[1])

Curvifloruside A[1]) (**1**) was obtained as an amorphous solid. Its molecular formula was determined as $C_{26}H_{38}O_9$ on the basis of the quasimolecular-ion peak at *m/z* 493.2448 ($[M-H]^-$) in the HR-FAB-MS (neg.). The IR spectrum suggested the presence of OH groups (3430 cm^{-1}), and the absorptions at 1735 and 1636 cm^{-1}, and the ^{13}C-NMR signals at δ 177.4, 163.7, and 121.7 (*Table 1*) revealed the presence of an α,β-unsaturated γ-lactone. The ^1H-NMR spectrum of **1** (*Table 1*) showed the presence of three quaternary Me groups at δ(H) 1.05, 1.06, and 1.96 (each *s*). Acid hydrolysis of **1** afforded D-glucose and the known aglycone **8** [9], which were detected by TLC with

Table 1. *^1H- and ^{13}C-NMR Data* (400 and 100 MHz, resp.) *of Compounds* **1** *and* **4**[1]). δ in ppm, *J* in Hz[a]).

	1[b])		**4**[c])	
	δ(H)	δ(C)	δ(H)	δ(C)
CH_2(1)	0.95 (*ddd*, *J* = 13.6, 12.6, 3.8, H_α), 1.57–1.58 (*m*, H_β)	37.2 (*t*)	1.01–1.03 (*m*, H_α), 2.10–2.11 (*m*, H_β)	37.6 (*t*)
CH_2(2)	1.91–1.92 (*m*, H_α), 1.61–1.62 (*m*, H_β)	19.8 (*t*)	0.85–0.86 (*m*, H_α), 1.16–1.18 (*m*, H_β)	26.5 (*t*)
CH_2(3)	1.81–1.83 (*m*, H_α), 1.10 (*ddd*, *J* = 13.6, 13.6, 3.8)	37.0 (*t*)	2.21–2.23 (*m*, H_α), 0.81–0.82 (*m*, H_β)	43.9 (*t*)
C(4)		39.4 (*s*)		40.3 (*s*)
CH(5)	1.29 (*d*, *J* = 12.6, H_β)	53.8 (*d*)	1.34 (*d*, *J* = 12.6, H_β)	55.3 (*d*)
CH_2(6)	1.44–1.45 (*m*, 2 H)	19.5 (*t*)	1.25–1.26 (*m*), 1.87–1.89 (*m*)	23.6 (*t*)
CH_2(7)	1.98–2.00 (*m*, H_α), 2.41–2.43 (*m*, H_β)	30.1 (*t*)	2.10–2.11 (*m*, H_α), 2.48 (*d*, *J* = 13.8, H_β)	37.1 (*t*)
C(8)		130.9 (*s*)		151.1 (*s*)
C(9) or CH(9)		138.8 (*s*)	2.27 (*dd*, *J* = 12.6, 6.6)	51.7 (*d*)
C(10)		38.9 (*s*)		42.5 (*s*)
CH_2(11)	1.76–77 (*m*, H_α), 2.89 (*dd*, *J* = 14.9, 6.3, H_β)	33.4 (*t*)	1.54–1.55 (*m*, H_α), 2.56 (*dd*, *J* = 13.6, 6.5, H_β)	27.4 (*t*)
CH(12)	4.75 (*t*, *J* = 8.6)	77.7 (*d*)	4.95 (*dd*, *J* = 9.3, 3.5)	75.9 (*d*)
C(13)		163.7 (*s*)		156.2 (*s*)
CH(14)	4.93 (*s*, H_β)	70.8 (*d*)	6.23 (*s*)	114.5 (*d*)
C(15)		121.7 (*s*)		116.4 (*s*)
C(16)		177.4 (*s*)		175.7 (*s*)
Me(17)	1.96 (*s*)	9.1 (*q*)	1.76 (*s*)	8.0 (*q*)
Me(18)	1.05 (*s*)	28.1 (*q*)	0.96 (*s*)	27.5 (*q*)
CH_2(19)	4.20 (*d*, *J* = 9.6), 4.08 (*d*, *J* = 9.6)	73.8 (*t*)	3.26 (*d*, *J* = 11.3), 3.60 (*d*, *J* = 11.3)	64.5 (*t*)
Me(20)	1.06 (*s*)	19.7 (*q*)	0.88 (*s*)	18.4 (*q*)
CH(1′)	4.69 (*d*, *J* = 7.8)	104.9 (*d*)		
CH(2′)	3.32–3.34 (*m*)	75.2 (*d*)		
CH(3′)	3.30–3.31 (*m*)	78.3 (*d*)		
CH(4′)	3.28–3.29 (*m*)	71.7 (*d*)		
CH(5′)	3.20 (*t*, *J* = 8.8)	78.8 (*d*)		
CH_2(6′)	3.86 (*dd*, *J* = 11.8, 2.3), 3.68 (*dd*, *J* = 11.8, 5.3)	62.8 (*t*)		

[a]) The assignments were based on $^1H,^1H$-COSY, HMQC, and HMBC experiments. [b]) Recorded in C_5D_5N. [c]) Recorded in $CDCl_3$.

reference samples. Besides the signals for the β-D-glucopyranosyl group, 20 C-atom signals were observed in the ^{13}C-NMR spectrum of **1**, including those of three Me and one CH_2OH group, indicating an abietane diterpene structure containing an α,β-unsaturated γ-lacton moiety. Comparison of the ^{13}C-NMR data of **1** with those of the corresponding aglycone pholgacantholide C (**8**) [9] showed a close agreement, pointing to **1** being the glucoside of pholgacantholide C. The correlation δ(H) 4.69 (H–C(1′))/δ(C) 73.8 (C(19)) in the HMBC experiment showed that the β-D-glucopyranosyl moiety must be located at C(19). This was consistent with C(19) being shifted from δ 64.2 in **8** to 73.8 in **1**. Most of the structure of **1** was elucidated by HMBC and NOESY experiments (*Fig. 1*). To discriminate lactonization between C(16) and C(12) from lactonization between C(16) and C(14), **1** was acetylated to give a diacetate **9** identical to that described in [9]. The HMBC between H–C(14) and the C=O(Ac) of **9** formed by acetylation of OH–C(14) of **1**, suggested the lactonization in **9** between C(16) and C(12). The relative configuration at C(14) of **1** was elucidated by a NOESY correlation between H–C(14) and H_β–C(7) (*Fig. 1*). Consequently, the structure of curvifloruside A (**1**) was elucidated as (4α,5β,10α,14α)-14,19-dihydroxyabieta-8,13(15)-dieno-16,12-lactone 19-(β-D-glucopyranoside)[1]).

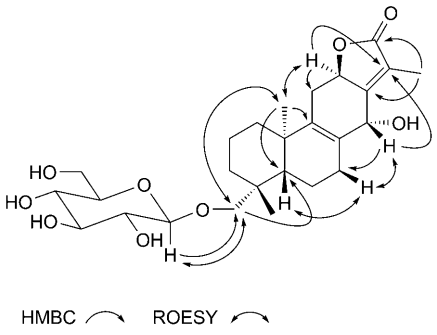


Fig. 1. *Key HMBC and ROESY correlations of* **1**

Curvifloruside B[1]) (**2**) was obtained as an amorphous solid. Its molecular formula was determined as $C_{35}H_{46}O_{13}$ on the basis of the quasimolecular-ion peak at *m/z* 673.2869 ($[M-H]^-$) in the HR-FAB-MS (neg.). The IR spectrum showed the presence of OH groups (3441 cm^{-1}), an α,β-unsaturated γ-lactone (1732 cm^{-1}), and an aryl group (1612, 1549, and 1461 cm^{-1}). The ^{1}H-NMR spectrum (*Table 2*) displayed the signals of three quaternary Me groups at δ(H) 0.99, 1.11, and 2.21 (each *s*), two MeO units at 3.78 (*s*, 6 H), two CH–O groups at 4.83 (*dd*, $J = 6.6, 5.0$ Hz) and 5.00 (*s*), and 2 aromatic H-atoms at 7.75 (*s*). On the other hand, the ^{13}C-NMR signals (*Table 2*) at δ(C) 120.9 (*s*), 108.7 (2 *d*), 148.6 (2 *s*), and 142.7 (*s*) indicated that **2** is endowed with a symmetrical tetrasubstituted benzene moiety. From the HMBC experiment, this moiety was determined to be a 4-hydroxy-3,5-dimethoxybenzoyl group. Comparison of the ^{1}H- and ^{13}C-NMR spectral data of **2** and **1** revealed that **2** was an *O*-acylated product of **1**. The correlations δ(H) 5.09 (H–C(1′))/δ(C) 75.6 (*t*, C(19)) and δ(H) 5.92 (H–C(2′))/δ(C) 166.2 (C(7″)) in the HMBC experiment indicated that the glucosyl

Table 2. *^{1}H- and ^{13}C-NMR Data* (400 and 100 MHz, resp.) *of Compounds* **2** *and* **3**[1]). δ in ppm, J in Hz[a]).

	2[b])		**3**[c])	
	δ(H)	δ(C)	δ(H)	δ(C)
CH_2(1)	0.68 (*t*, J = 12.7, H_α), 1.44–1.45 (*m*, H_β)	36.0 (*t*)	1.15–1.17 (*m*, H_α), 1.51–1.53 (*m*, H_β)	36.3 (*t*)
CH_2(2)	1.53–1.54 (*m*, H_α), 1.86–1.88 (*m*, H_β)	20.4 (*t*)	1.28–1.29 (*m*, H_α), 1.32–1.33 (*m*, H_β)	20.4 (*t*)
CH_2(3)	1.45–1.47 (*m*, H_α), 0.84 (*dd*, J = 13.1, 3.7, H_β)	38.0 (*t*)	0.93–0.95 (*m*, H_α), 1.30–1.31 (*m*, H_β)	38.2 (*t*)
C(4)		37.6 (*s*)		41.6 (*s*)
CH(5)	0.98 (*d*, J = 12.6, H_β)	52.5 (*d*)	1.12 (*d*, J = 12.3, H_β)	52.8 (*d*)
CH_2(6)	1.23–1.24 (*m*), 1.45–1.47 (*m*)	19.0 (*t*)	1.51–1.53 (*m*), 1.82–1.83 (*m*)	19.5 (*t*)
CH_2(7)	1.57 (*dd*, J = 13.1, 6.2, H_α), 2.43–2.44 (*m*, H_β)	29.9 (*t*)	1.74–1.76 (*m*, H_α), 1.91–1.92 (*m*, H_β)	26.5 (*t*)
C(8)		131.3 (*s*)		135.0 (*s*)
C(9)		136.2 (*s*)		135.1 (*s*)
C(10)		38.7 (*s*)		38.5 (*s*)
CH_2(11)	2.82 (*dd*, J = 15.0, 6.2, H_α), 1.78 (*t*, J = 6.3, H_β)	33.4 (*t*)	3.10–3.12 (*m*, H_α), 1.82–1.83 (*m*, H_β)	33.8 (*t*)
CH(12)	4.83 (*dd*, J = 6.6, 5.0)	78.4 (*d*)	5.06 (*dd*, J = 6.6, 3.2)	78.0 (*d*)
C(13)		163.2 (*s*)		163.1 (*s*)
CH(14) or C(14)	5.00 (*s*, H_β)	70.0 (*d*)		186.4 (*s*)
C(15)		120.7 (*s*)		121.4 (*s*)
C(16)		175.4 (*s*)		175.5 (*s*)
Me(17)	2.21 (*s*)	9.6 (*q*)	2.11 (*s*)	9.8 (*q*)
Me(18)	0.99 (*s*)	28.6 (*q*)	0.99 (*s*)	28.9 (*q*)
CH_2(19)	4.05 (*d*, J = 9.5), 3.79 (*d*, J = 9.5)	75.6 (*t*)	3.96 (*d*, J = 9.6), 3.70 (*d*, J = 9.6)	75.8 (*t*)
Me(20)	1.11 (*s*)	19.0 (*q*)	1.08 (*s*)	19.0 (*q*)
CH(1′)	5.09 (*d*, J = 7.9)	102.8 (*d*)	4.62 (*d*, J = 7.6)	102.7 (*d*)
CH(2′)	5.92 (*t*, J = 8.1)	75.8 (*d*)	5.03 (*t*, J = 8.0)	75.6 (*d*)
CH(3′)	4.43 (*t*, J = 10.7)	76.5 (*d*)	3.72 (*t*, J = 7.6)	76.4 (*d*)
CH(4′)	4.34 (*t*, J = 9.0)	72.0 (*d*)	3.78–3.80 (*m*)	71.7 (*d*)
CH(5′)	4.05–4.07 (*m*)	78.9 (*d*)	3.84–3.86 (*m*)	78.9 (*d*)
CH(6′)	4.39 (*dd*, J = 12.0, 5.6), 4.61 (*dd*, J = 12.0, 2.2)	62.7 (*t*)	3.52 (*dd*, J = 11.6, 1.8), 3.83 (*dd*, J = 11.6, 5.2)	62.6 (*t*)
C(7″)		166.2 (*s*)		167.0 (*s*)
C(1″)		120.9 (*s*)		121.4 (*s*)
CH(2″,6″)	7.75 (*s*, 2 H)	108.7 (*d*)	7.35 (*s*, 2 H)	108.6 (*d*)
C(3″,5″)		148.6 (*s*)		148.5 (*s*)
C(4″)		142.7 (*s*)		141.8 (*s*)
*Me*O–C(3″,5″)	3.78 (*s*, 6 H)	56.5 (*q*)	3.89 (*s*, 6 H)	56.8 (*q*)

[a]) The assignments were based on ^{1}H,^{1}H-COSY, HMQC, and HMBC experiments. [b]) Recorded in C_5D_5N. [c]) Recorded in CD_3OD.

group was located at C(19) and that the substituted benzoyl moiety was positioned at C(2′). As in the case of **1**, the relative configuration of **2** was deduced by a NOESY experiments. Thus, curvifloruside B (**2**) was identified as (4α,5β,10α,14α)-14,19-

dihydroxyabieta-8,13(15)-dieno-16,12-lactone 19-[2-*O*-(4-hydroxy-3,5-dimethoxybenzoyl)-*β*-D-glucopyranoside][1]).

Curvifloruside C[1]) (**3**) was obtained as an amorphous solid. Its molecular formula was determined as $C_{35}H_{44}O_{13}$ on the basis of the quasimolecular-ion peak at *m/z* 671.2714 ($[M-H]^-$) in the HR-FAB-MS (neg.). The IR spectrum showed the presence of OH groups (3441 cm^{-1}), an *α*,*β*-unsaturated *γ*-lactone (1732 cm^{-1}), and an aryl group (1612, 1549, and 1461 cm^{-1}). The ^{1}H-NMR spectrum (*Table 2*) displayed the signals of three quaternary Me groups at *δ*(H) 0.99, 1.11, and 2.11 (each *s*), two MeO groups at 3.89 (*s*, 6 H), one CH–O group at 5.06 (*dd*, *J* = 6.6, 3.2 Hz), and two aromatic H-atoms at 7.35 (*s*). The comparison of the ^{13}C-NMR data of **3** and **2** (*Table 2*) showed that the signal of C(14) of **3** was at *δ* 186.4 instead of *δ* 70.0 as observed in **2**, indicating that C(14) in **3** was a C=O C-atom. On the other hand, the correlations *δ*(H) 4.62 (H–C(1′)))/*δ*(C) 75.8 (*t*, C(19)) and *δ*(H) 5.03 (H–C(2′))/*δ*(C) 167.0 (C(7″)) were observed in the HMBC experiments, indicating that the glucosyl group was located at C(19) and the benzoyl moiety at C(2′), respectively (*Fig. 2*). Thus, curvifloruside C (**3**) was elucidated as (4*α*,5*β*,10*α*)-19-hydroxy-14-oxoabieta-8,13(15)-dieno-16,12-lactone 19-[2-*O*-(4-hydroxy-3,5-dimethoxybenzoyl)-*β*-D-glucopyranoside][1]).

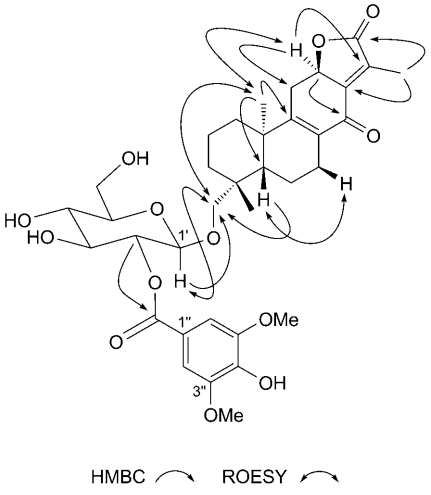


Fig. 2. *Key HMBC and ROESY correlations of* **3**

Compound **4** was obtained as an amorphous solid. Its molecular formula was determined as $C_{20}H_{28}O_3$ on the basis of the molecular-ion peak at *m/z* 316.2118 (M^-) in the HR-FAB-MS (neg.). The IR spectrum showed the presence of OH groups (3441 cm^{-1}) and an *α*,*β*-unsaturated *γ*-lactone (1732 cm^{-1}). In comparison with the NMR of jolkinolide E (**11**) [10], the presence of a CH_2OH group (*δ*(H) 3.26 and 3.60 (each *d*, *J* = 11.3 Hz, 1 H); *δ*(C) 64.5) and the lack of one Me group in **4** (**11**: *δ*(H) 0.86 (Me(19)); *δ*(C) 22.0) were the main differences. Moreover, the correlations of the signals at *δ*(H) 3.26 and 3.60 with those at *δ*(C) 55.3 (C(5)), 18.4 (C(20)), and 40.3 (C(4)) confirmed the presence of OH–C(19). Therefore, the structure of **4** was elucidated as 19-hydroxyjolkinolide E[1]).

Curvifloruside D[1]) (**5**) was obtained as a white solid. Its molecular formula was determined as $C_{21}H_{32}O_7$ on the basis of the quasimolecular-ion peak at *m/z* 395.2065 ($[M-H]^-$) in the HR-FAB-MS (neg.). The glycopyranosyl group of **5** was indicated by anomeric CH resonances at δ(H) 5.11 (*d*, $J=7.8$ Hz) and δ(C) 103.9 and by its fragment-ion peaks at 395 ($[M-H]^-$) and 233 ($[M-H-162]^-$) in its FAB-MS (neg.). The ^{1}H-NMR data of **5** indicated the presence of four quaternary Me groups at δ(H) 0.99, 1.63, 1.73, and 2.15 (each *s*) and two olefinic H-atoms at δ(H) 6.08 and 5.69 (each *s*). Besides the signals of the β-D-glucopyranosyl group, fifteen C-atom signals were observed in the ^{13}C-NMR spectrum, including those of four Me, two CH_2, and five CH groups (two olefinic CH), and of four quaternary C-atoms (one COOH and two olefinic C). The ^{1}H- and ^{13}C-NMR signals of **5** were assigned by COSY and HMQC experiments. The ^{13}C-NMR, together with the HMBC, indicated the presence of the sequence $CH_2C(=O)CH=CMe_2$ located at C(7) by the correlations δ(H) 2.76 (CH_2)/ δ(C) 48.3 (C(7)) (*Fig. 3*). Careful evaluation of the ^{1}H- and ^{13}C-NMR data of **5** revealed that its structure possesses a sesquiterpene skeleton of the α-bergamotene (=2,6-dimethyl-6-(4-methylpent-3-en-1-yl)bicyclo[3.1.1]hept-2-ene) type [11]. Its ^{1}H,^{1}H-COSY plot showed the presence of a sequence CH−O−CH−CH=C. The HMBC experiment showed a correlation of the C-atom at δ(C) 77.7 (C(1)) with the anomeric glucosyl H-atom at δ(H) 5.11 (H−C(1′)), suggesting that the glucose is attached to C(1). On the basis of the evidences mentioned above, the structure of curvifloruside D (**5**) was determined to be 9-oxo-α-bergamoten-1-yl β-D-glucopyranoside[1]).

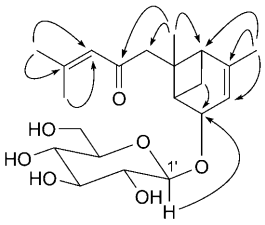
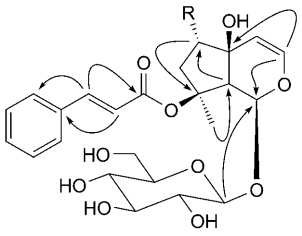


Fig. 3. *Key HMBC of* **5**

Curvifloruside E[1]) (**6**) was obtained as a white solid. Its molecular formula was determined as $C_{24}H_{30}O_{10}$ on the basis of the quasimolecular-ion peak at *m/z* 477.1853 ($[M-H]^-$) in the HR-FAB-MS (neg.). The ^{1}H-NMR spectrum of **6** contained the signals for two *trans*-positioned olefinic H-atoms at δ 6.67 and 7.78 (each *d*, $J=$ 16.0 Hz), five related aromatic H-atoms at δ 7.45 (*dd*, $J=8.0$, 1.6 Hz, H−C(2″,6″)), 7.27 (*t*, $J=8.1$ Hz, H−C(3″,5″)), and 7.42 (*t*, $J=8.1$ Hz, H−C(4″)), and two *cis*-positioned olefinic H-atoms at δ 4.96 and 6.36 (each *d*, $J=6.4$ Hz). Comparison of the NMR data of **6** with those of harpagoside (**13**) indicated that their structures were similar [12]. The FAB-MS (neg.) of **6** with $[M-H]^-$ at *m/z* 477 suggested a lack of 16 mass units compared to that of **13**. The presence of an additional CH_2 in **6** (δ(C) 30.0 (*t*)) and the absence of the signal at δ(C) 77.6 (*d*) of **13** were the main differences. On the basis of these evidences, **6** must be a deoxyharpagoside. This was confirmed by ^{1}H,^{1}H-COSY, HMQC, and HMBC experiments (*Fig. 4*). Thus, the structure of curvifloruside E (**6**) was elucidated to be 6-deoxyharpagoside[1]).



6 R = H
7 R = OH

Fig. 4. *Key HMBC of* **6** *and* **7**

Curvifloruside F[1]) (**7**) was obtained as a white solid. Its molecular formula was determined as $C_{24}H_{30}O_{11}$ on the basis of the quasimolecular-ion peak at *m*/*z* 493.1701 ($[M-H]^-$) in the HR-FAB-MS (neg.). The ^{1}H- and ^{13}C-NMR spectra of **7** were similar to those of harpagoside (**13**), except for the shift of C(8) from δ(C) 88.8 in **13** to δ(C) 85.1 in **7** [12]. In the ^{1}H-NMR spectrum, the signal of H–C(6) was shifted from δ 3.75 (*d*, *J* = 3.8 Hz) in **13** to δ 4.28 (*dd*, *J* = 12.1, 6.6 Hz) in **7**. The different coupling constants suggested an inverted configuration at C(6) (*Fig. 4*), leading to the structure of 6-epiharpagoside[1]) (**7**) for curvifloruside F.

Besides the seven new compounds, eleven known compounds were isolated from the plant. Comparison of the physicochemical and NMR properties with the reported data allowed for their structures to be identified as phlogacantholide C (**8**) [9], phlogacantholide C diacetate (**9**) [9], phlogacanthoside B (**10**) [9], jolkinolide E (**11**) [10], caprarioside (**12**) [13], harpagoside (**13**) [12], 8-*O*-(4-hydroxycinnamoyl)harpagide (**14**) [14], 8-*O*-feruloylharpagide (**15**) [12], lup-20(29)-ene-3,23-diol (**16**)[15], acanthoside B (**17**) [14], and acetylmartynoside A (**18**) [16]. Among them, the sesquiterpene and iridoid glycosides were isolated for the first time from the genus of *Phlogacanthus*. These results are valuable for future investigations on the chemical components distribution and their bioactivity in species of the genus *Phlogacanthus*.

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Experimental Part

General. Column chromatography (CC): *Qingdao* silica gel (SiO_2, 200–300 mesh) and *Sephadex LH-20*. TLC: *Qingdao* precoated plates; eluents: MeOH/$CHCl_3$ 1:100, 1:50, 1:20, and 1:10, (for *Fractions A*), and MeOH/$CHCl_3$ 1:1 (for *Fractions B*). Optical rotation: *Horiba-SEAP-300* sensitive polarimeter. UV Spectra: *Shimazhu 210A* spectrophotometer in MeOH; λ_{max} (log ε) in nm. IR Spectra: *Bio-Rad*-FTS spectrometer; in KBr pellets; $\tilde{\nu}$ in cm^{-1}. NMR Spectra: *Bruker-AM-400* or *-DRX-500* spectrometer; in $CDCl_3$ or C_5D_5N; δ in ppm with ref. to the signal of $CDCl_3$ or C_5D_5N with Me_4Si as internal standard, *J* in Hz. MS: *VG-AutoSpec-3000* spectrometer; in *m*/*z* (rel. %).

Plant Material. The roots of *Phlogacanthus curviflorus* (WALL) NEES were collected in July 2002 in Xishuangbanna, Yunnan, P. R. China. The plant material was identified by Dr. *Jian-Ying Xiang*. A voucher specimen was deposited with the State Key Laboratory of Phytochemistry and Plant Resources

in West China, Kunming Institute of Botany, Chinese Academy of Sciences, Kunming 650204, Yunnan, P. R. China.

Extraction and Isolation. The air-dried roots (5.2 kg) were extracted twice with 90% EtOH/H_2O at r.t. The solvent was evaporated at $< 50°$ to give a deep-brown waxy residue which was suspended in H_2O and extracted with petroleum ether (3×2 l) and BuOH (3×2 l). The BuOH extract (103 g) was fractionated by CC (SiO_2 (1000 g), 200–300 mesh, MeOH/$CHCl_3$ 1:100, 1:50, 1:20, 1:10, 1:5, and 1:2, each 2 l) to afford several fractions. The second fraction (2.3 g) was purified by repeated CC (SiO_2, MeOH/$CHCl_3$ 1:100 and 1:50; then *Sephadex LH-20*, MeOH/$CHCl_3$ 1:1): **9** (18 mg) and **16** (451 mg). The third fraction (4.1 g) was purified by repeated CC (SiO_2, MeOH/$CHCl_3$ 1:50 → 1:20; then *Sephadex LH-20*, MeOH/$CHCl_3$ 1:1): **8** (2.51 g) and **18** (82 mg). The forth fraction (7.8 g) was purified by CC (SiO_2, $CHCl_3$/MeOH 30:1 → 2:1) to give *Frs. A* and *B*. After repeated CC (*RP18* SiO_2, 80% MeOH/H_2O; then SiO_2, $CHCl_3$/MeOH 10:1 → 4:1), *Fr. A* afforded **2** (71 mg), **3** (43 mg), and **6** (23 mg), and *Fr. B* gave **5** (8 mg) and **10** (42 mg). The fifth fraction (1.9 g) was purified by CC (SiO_2, $CHCl_3$/MeOH 20:1 → 2:1; then *Sephadex LH-20*, MeOH: **4** (33 mg), **11** (6 mg), and **17** (17 mg). The sixth fraction (11.5 g) was purified by CC (SiO_2, $CHCl_3$/MeOH 20:1 → 1:1) and then repeated CC (*RP18* SiO_2, MeOH/H_2O 6:4, 4:1, and 9:1, each 1 l): **1** (376 mg), **7** (15 mg), **12** (198 mg), **13** (71 mg), **14** (18 mg), and **15** (176 mg).

Acidic Hydrolysis. A mixture of **1** (5 mg), MeOH (1.0 ml), and 2M HCl (1.0 ml) was refluxed in a boiling water bath for 2 h. The hydrolysate was allowed to cool, diluted twofold with dist. H_2O, and partitioned between H_2O and AcOEt. The aq. layer was neutralized and concentrated to give a residue. Glucose was identified from the residue by TLC comparison (BuOH/AcOH/H_2O 5:1:5, upper layer) with an authentic sample.

Curvifloruside A (= *(4α,5β,10α,14α)-14,19-Dihydroxyabieta-8,13(15)-dieno-16,12-lactone 19-(β-*D*-glucopyranoside)* = rel-*(4*R*,4a*S*,7*R*,10a*R*,11b*R*)-4-[(β-*D*-Glucopyranosyloxy)methyl]-2,3,4,4a,5,6,7,10a, 11,11b-decahydro-7-hydroxy-4,8,11b-trimethylphenanthro[3,2-*b*]furan-9(1*H*)-one*; **1**): White powder. $[\alpha]_D^{20} = -181$ ($c = 1.15$, MeOH). UV: 220 (1.23). IR: 3430, 2892, 2850, 1735, 1636, 1380, 1074, 1037, 1017. ^{1}H- and ^{13}C-NMR: *Table 1*. FAB-MS (neg.): 493 (100, $[M-H]^-$), 331 (9, $[M-H-162]^-$), 313 (25), 269 (10), 101 (27). HR-FAB-MS (neg.): 493.2448 ($[M-H]^-$, $C_{26}H_{37}O_9^-$; calc. 493.2437).

Curvifloruside B (= *(4α,5β,10α,14α)-14,19-Dihydroxyabieta-8,13(15)-dieno-16,12-lactone 19-[2-*O*-(4-hydroxy-3,5-dimethoxybenzoyl)-β-*D*-glucopyranoside]* = rel-*(4*R*,4a*S*,7*R*,10*R*,11b*R*)-2,3,4,4a,5,6,7, 10a,11,11b-Decahydro-7-hydroxy-4-{[[2-*O*-(4-hydroxy-3,4-dimethoxybenzoyl)-β-*D*-glucopyranosyl]oxy}methyl}-4,8,11b-trimethylphenanthro[3,2-*b*]furan-9(1*H*)-one*; **2**): White powder. $[\alpha]_D^{20} = -79$ ($c = 1.0$, MeOH). UV: 218 (1.62), 277 (0.69). IR: 3441 (OH), 2939, 2848, 1732 (C=O), 1715 (C=O), 1612, 1549, 1514, 1461, 1423, 1337, 1220, 1116, 1079, 1033, 1018. ^{1}H- and ^{13}C-NMR: *Table 2*. FAB-MS (neg.): 673 (100, $[M-H]^-$). HR-FAB-MS (neg.): 673.2869 ($[M-H]^-$, $C_{35}H_{45}O_{13}^-$; calc. 673.2860).

Curvifloruside C (= *(4α,5β,10α)-19-Hydroxy-14-oxoabieta-8,13(15)-dieno-16,12-lactone 19-[2-*O*-(4-hydroxy-3,5-dimethoxybenzoyl)-β-*D*-glucopyranoside]* = rel-*(4*R*,4a*S*,10a*R*,11b*R*)-1,2,3,4,4a,5,6,10a, 11,11b-Decahydro-4-{[[2-*O*-(4-hydroxy-3,4-dimethoxybenzoyl)-β-*D*-glucopyranosyl]oxy}methyl}-4,8, 11b-trimethylphenanthro[3,2-*b*]furan-7,9-dione*; **3**): White powder. $[\alpha]_D^{20} = -56$ ($c = 0.7$, MeOH). UV: 221 (1.71), 285 (0.72). IR: 3446 (OH), 2941, 2842, 1735 (C=O), 1718 (C=O), 1614, 1543, 1517, 1463, 1221, 1118, 1083, 1016. ^{1}H- and ^{13}C-NMR: *Table 2*. FAB-MS (neg.): 671 (100, $[M-H]^-$), 491 (15), 329 (42), 197 (45). HR-FAB-MS (neg.): 671.2714 ($[M-H]^-$, $C_{35}H_{43}O_{13}^-$; calc. 671.2703).

19-Hydroxyjolkinolide E (= rel-*(4*R*,4a*S*,10a*R*,11a*R*,12b*S*)-2,3,4,4a,5,6,10a,11,11a,11b-Decahydro-4-(hydroxymethyl)-4,8,11b-trimethylphenanthro[3,2-*b*]furan-9(1*H*)-one*; **4**): White powder. IR: 3441, 1732, 1280, 1067. ^{1}H- and ^{13}C-NMR: *Table 1*. EI-MS: 316 (100, M^+). HR-EI-MS: 316.2118 (M^+, $C_{20}H_{28}O_3^+$; calc. 316.2038).

Curvifloruside D (= *9-Oxo-α-bergamoten-1-yl β-*D*-Glucopyranoside* = *1-[4-(β-*D*-Glucopyranosyloxy)-2,6-dimethylbicyclo[3.1.1]hept-2-en-6-yl]-4-methylpent-3-en-2-one*; **5**): White powder. $[\alpha]_D^{20} = -30.0$ ($c = 0.35$, MeOH). UV: 227. IR: 3421 (OH), 2929, 2873, 1757 (C=O), 1677 (C=C), 1620 (C=C), 1446, 1377, 1076, 1036. ^{1}H-NMR (C_5D_5N, 400 MHz)[1]): 4.75 (br. *s*, H–C(1)); 5.69 (br. *s*, H–C(2)); 2.32 (*dd*, $J =$ 6.2, 2.2, H–C(4)); 1.77 (*t*, $J = 9.0$, 1 H–C(5)); 2.25 (*m*, H–C(5)); 2.88 (*m*, H–C(6)); 2.76 (*s*, 2 H–C(8)); 6.08 (*s*, H–C(10)); 2.15 (*s*, Me(12)); 1.73 (*s*, Me(13)); 0.99 (*s*, Me(14)); 1.63 (*s*, Me(15)); 5.11 (*d*, $J = 7.8$, H–C(1′)); 4.05 (*m*, H–C(2′)); 3.98 (*m*, H–C(3′)); 4.30 (*m*, H–C(4′)); 4.27 (*m*, H–C(5′)); 4.40 (*dd*, $J =$

11.7, 5.1, 1 H–C(6′)); 4.54 (*dd*, *J* = 11.7, 2.2, 1 H–C(6′)). ^{13}C-NMR (C_5D_5N, 100 MHz)[1]): 77.7 (*d*, C(1)); 117.8 (*d*, C(2)); 147.8 (*s*, C(3)); 46.4 (*d*, C(4)); 29.4 (*t*, C(5)); 45.4 (*d*, C(6)); 48.3 (*s*, C(7)); 51.9 (*t*, C(8)); 200.2 (*s*, C(9)); 125.6 (*d*, C(10)); 154.2 (*s*, C(11)); 20.6 (*q*, C(12)); 27.4 (*q*, C(13)); 18.0 (*q*, C(14)); 22.9 (*q*, C(15)); 103.9 (*d*, C(1′)); 75.5 (*d*, C(2′)); 78.5 (*d*, C(3′)); 71.8 (*d*, C(4′)); 78.6 (*d*, C(5′)); 62.9 (*t*, C(6′)). FAB-MS (neg.): 395 (100, $[M-H]^-$), 233 (37). HR-FAB-MS (neg.): 395.2065 ($[M-H]^-$, $C_{21}H_{31}O_7^-$; calc. 395.2069).

Curvifloruside E (=*6-Deoxyharpagoside*=*(2*E*)-3-Phenylprop-2-enoic Acid* rel-*(1*R*,4a*R*,7*R*,7a*R*)-1-(β-*D*-Glucopyranosyloxy)-1,4a,5,6,7,7a-hexahydro-4a-hydroxy-7-methylcyclopenta[*c*]pyran-7-yl Ester*; **6**): White powder. ^{1}H-NMR (CD_3OD, 400 MHz)[1]): 6.26 (*s*, H–C(1)); 6.36 (*d*, *J* = 6.4, H–C(3)); 4.96 (*d*, *J* = 6.4, H–C(4)); 1.16–1.18 (*m*, H_α–C(6)); 1.28–1.30 (*m*, H_β–C(6)); 1.74–1.76 (*m*, H_α–C(7)); 2.17–2.18 (*m*, H_β–C(7)); 3.01 (*s*, H–C(9)); 1.48 (*s*, Me(10)); 7.45 (*d*, *J* = 8.2, H–C(2″), H–C(6″)); 7.27 (*t*, *J* = 8.2, H–C(3″), H–C(5″)); 7.42 (*t*, *J* = 8.3, H–C(4″)); 7.78 (*d*, *J* = 16.0, H–C(7″)); 6.67 (*d*, *J* = 16.0, H–C(8″)); 5.01 (*d*, *J* = 7.8, H–C(1′)); 3.76–3.78 (*m*, H–C(2′)); 3.69–3.71 (*m*, H–C(3′)); 3.52–3.54 (*m*, H–C(4′)); 3.71–3.72 (*m*, H–C(5′)); 3.86 (*dd*, *J* = 11.8, 2.0, 1 H–C(6′)); 4.07 (*dd*, *J* = 11.8, 5.6, 1 H–C(6′)). ^{13}C-NMR (CD_3OD, 100 MHz)[1]): 94.3 (*d*, C(1)); 142.9 (*d*, C(3)); 107.2 (*d*, C(4)); 73.0 (*s*, C(5)); 30.0 (*t*, C(6)); 43.8 (*t*, C(7)); 88.0 (*s*, C(8)); 55.8 (*d*, C(9)); 22.3 (*q*, C(10)); 134.8 (*s*, C(1″)); 129.2 (2*d*, C(2″,6″)); 130.0 (2*d*, C(3″,5″)); 130.5 (*d*, C(4″)); 119.4 (*d*, C(7″)); 144.9 (*d*, C(8″)); 166.4 (*s*, C=O); 99.3 (*d*, C(1′)); 75.2 (*d*, C(2′)); 78.5 (*d*, C(3′)); 71.8 (*d*, C(4′)); 78.8 (*d*, C(5′)); 63.0 (*t*, C(6′)). FAB-MS (neg.): 477 (100, $[M-H]^-$). HR-FAB-MS (neg.): 477.1853 ($[M-H]^-$, $C_{24}H_{29}O_{10}^-$; calc. 477.1761).

Curvifloruside F (=6-Epiharpagoside=*(2*E*)-3-Phenylprop-2-enoic Acid* rel-*(1*R*,4a*R*,5*R*,7*R*,7a*S*)-1-(β-*D*-Glucopyranosyloxy)-1,4a,5,6,7,7a-hexahydro-4a,5-dihydroxy-7-methylcyclopenta[*c*]pyran-7-yl Ester*; **7**): White powder. ^{1}H-NMR (CD_3OD, 400 MHz)[1]): 6.07 (*d*, *J* = 1.3, H–C(1)); 6.47 (*d*, *J* = 6.5, H–C(3)); 5.18 (*dd*, *J* = 6.5, 1.5, H–C(4)); 4.28 (*dd*, *J* = 12.1, 6.6, H–C(6)); 2.32 (*dd*, *J* = 13.7, 6.7, 1 H–C(7)); 1.65 (*t*, *J* = 13.5, 1 H–C(7)); 2.74 (*s*, H–C(9)); 1.54 (*s*, Me(10)); 7.61 (*d*, *J* = 8.1, H–C(2″), H–C(6″)); 7.40 (*t*, *J* = 8.1, H–C(3″), H–C(5″)); 7.59 (*t*, *J* = 8.1, H–C(4″)); 7.67 (*d*, *J* = 16.0, H–C(7″))); 6.51 (*d*, *J* = 16.0, H–C(8″)); 4.62 (*d*, *J* = 7.9, H–C(1′)); 3.20 (*dd*, *J* = 9.0, 8.0, H–C(2′)); 3.41 (*t*, *J* = 8.9, H–C(3′)); 3.34–3.32 (*m*, H–C(4′)); 3.31–3.29 (*m*, H–C(5′)); 3.93 (*dd*, *J* = 12.2, 1.9, 1 H–C(6′)); 3.74 (*dd*, *J* = 12.2, 5.4, 1 H–C(6′)). ^{13}C-NMR (CD_3OD, 100 MHz)[1]): 93.9 (*d*, C(1)); 143.4 (*d*, C(3)); 103.5 (*d*, C(4)); 73.3 (*s*, C(5)); 76.4 (*d*, C(6)); 45.5 (*t*, C(7)); 85.1 (*s*, C(8)); 56.4 (*d*, C(9)); 22.1 (*q*, C(10)); 135.6 (*s*, C(1″)); 129.3 (2 *d*, C(2″,6″)); 130.1 (2*d*, C(3″,5″)); 131.6 (*d*, C(4″)); 146.4 (*d*, C(7″)); 119.7 (*d*, C(8″)); 168.6 (*s*, C=O); 99.8 (*d*, C(1′)); 74.5 (*d*, C(2′)); 77.6 (*d*, C(3′)); 71.7 (*d*, C(4′)); 78.1 (*d*, C(5′)); 62.9 (*t*, C(6′)). FAB-MS (neg.): 493 (100, $[M-H]^-$). HR-FAB-MS (neg.): 493.1701 ($[M-H]^-$, $C_{24}H_{29}O_{11}^-$; calc. 493.1709).

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