



CHLORINATED MACROCYCLIC BISBIBENZYLs FROM THE LIVERWORT *BAZZANIA TRILOBATA**

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Key Word Index—*Bazzania trilobata*; Hepaticae; liverwort; structural elucidation; chlorinated bisbibenzyls; phenanthrene.

Abstract—Bazzanines A–J, 10 cyclic bisbibenzyl derivatives with two biphenyl linkages and substituted with 1–6 chlorine atoms, as well as Bazzanin K, a new dichlorinated macrocycle consisting of a phenanthrene and a bibenzyl moiety also connected with two biphenyl linkages, have been isolated from the liverwort *Bazzania trilobata*. The structures have been elucidated based on extensive NMR spectral evidence and by mass spectrometry. © 1997 Elsevier Science Ltd

INTRODUCTION

Within the Hepaticae, the genus *Bazzania* with its several hundred species, mainly distributed in the tropics and subtropics, is a rich source of various types of secondary metabolites. So far, mostly terpenoids have been isolated from this genus [1–5]. *Bazzania trilobata* represents one of the four European species, that grow in dense, widespread pads on forest ground, boggy soil and trunks [6]. Earlier studies of the non-polar fractions revealed terpenoids and the caffeic acid ester of drimenol [4]. Continuing our studies on the secondary metabolites of liverworts, we now report new chlorinated phenolic compounds from the methanolic extract of *B. trilobata*.

RESULTS AND DISCUSSION

Air-dried plant material was first extracted with ether and then with methanol. The ethyl acetate-soluble fraction of the methanol extract was chromatographed on Sephadex LH-20. The resulting fractions were subjected to Vacuum Liquid Chromatography (VLC) and further purified by HPLC to yield bazzanins A–I (1–9), which derive from the known bisbibenzyl isoplagiochin C [7], bazzanin J (10), that was assumed to be a derivative of iso-

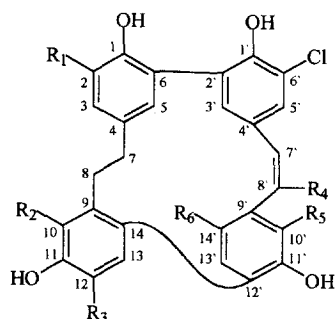
plagiochin D [7], and bazzanin K (11), which shows two biphenyl linkages between a phenanthrene and a bibenzyl moiety, that are not described so far. Non-chlorinated bibenzyls or bisbibenzyls could not be detected.

Bazzanin A (1)

Compound 1 was obtained as a white powder, whose molecular formula, $C_{28}H_{21}O_4Cl$, was established by DCI mass spectrometry. The mass spectrum showed for the $[M]^+$ peaks the typical isotope pattern ($456:458 = 100:32$) for one chlorine atom in the molecule. UV and IR data indicated the presence of phenolic hydroxyl groups (1300 and 1400 cm^{-1}) and a benzene ring (3300 and 1610 cm^{-1}), which was conjugated with a double bond ($\lambda_{\text{max}} 289\text{ nm}$). The ^1H and ^{13}C NMR spectra of 1 showed two benzylic methylene signals (δ_{H} 2.59, 4H, *m*, H-7 and H-8; δ_{C} 37.3 and 37.9, each *t*, C-7 and C-8) and two *cis*-olefinic protons (δ_{H} 6.47 and 6.69, each *d*, $J = 12.0\text{ Hz}$, H-7' and H-8'; δ_{C} 128.6 and 129.8, C-7' and C-8'), as well as 24 benzene ring carbons, including 11 aromatic protons. Detailed analysis of 2D NMR spectra, including ^1H – ^1H COSY, ^1H – ^{13}C COSY, HMBC and NOESY, were carried out. The linkages of the two bibenzyl units were obtained from HMBC. H-5 (δ_{H} 6.50, *d*, $J = 2.0\text{ Hz}$) showed a correlation with carbon C-2' (δ_{C} 127.5, *s*) and H-3' (δ_{H} 7.12, *d*, $J = 2.2\text{ Hz}$) correlated with carbon C-6 (δ_{C} 125.6, *s*). Comparable effects were observed between H-13 (δ_{H} 7.11, *d*, $J = 7.9\text{ Hz}$) and C-12' (δ_{C} 127.0, *s*), as well as between H-13' (δ_{H} 7.13,

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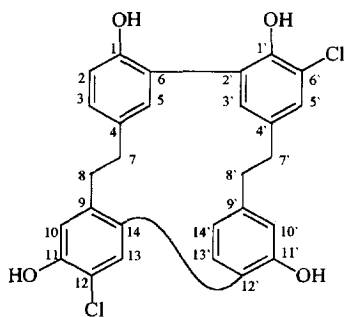
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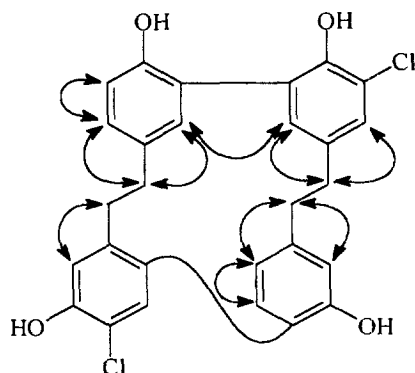
	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆
1	H	H	H	H	H	H
2	H	H	H	Cl	H	H
3	H	H	Cl	Cl	H	H
4	H	H	H	Cl	Cl	H
5	H	H	Cl	Cl	Cl	H
6	H	Cl	H	Cl	H	Cl
7	Cl	Cl	H	Cl	Cl	H
8	H	Cl	H	Cl	Cl	Cl
9	Cl	H	Cl	Cl	Cl	Cl

Fig. 1. Significant NOESY correlations of compound 1.

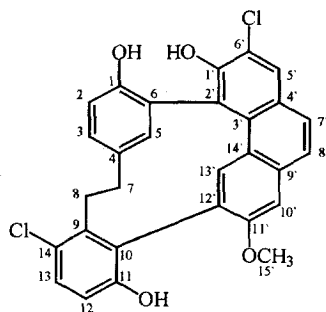
d, $J = 7.6$ Hz) and C-14 (δ_C 127.7, *s*). The position of the methylene bridge and the *cis*-double bond was confirmed by NOESY and HMBC experiments as described in Figs 1 and 2. The substitution pattern of the hydroxyl groups could also be detected by long-range correlations (Fig. 2). Due to the presence of a $^2J_{CH}$ -coupling from H-5' (δ_H 7.25, *d*, $J = 2.2$ Hz) to carbon C-6' (δ_C 122.1, *s*) in the HMBC spectrum, the position of the chlorine atom was determined. These 2J couplings can mainly be seen if the adjacent carbons bear an electronegative substituent, such as a hydroxyl group or a chlorine atom [8]. Because of the chemical



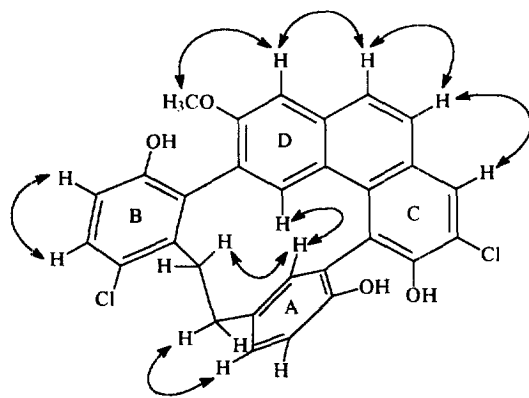
10



10



11



11

Fig. 2. Significant HMBC couplings of compounds 1 and 11.

shift of C-6' it can be excluded, that C-6' bears a hydroxyl group. The calculation of increments to estimate the shifts of ^{13}C NMR values [9] led to the conclusion that C-6' ($\delta_{\text{C}} 122.13$ s) had a chlorine atom, $\delta_{\text{C-calc.}} 122.3$, which is very close to $\delta_{\text{C-exp.}} 122.1$ found in the ^{13}C NMR spectrum. Structural elucidation leads to the conclusion that **1** represents the structure of 6'-chloroisoplagiochin C, given the name bazzanin A. The skeleton, isoplagiochin C, has already been published by Hashimoto *et al.* [7].

Bazzanin B (2)

The molecular formula of **2** was determined to be $\text{C}_{28}\text{H}_{20}\text{O}_4\text{Cl}_2$ by high resolution mass spectrometry ($[\text{M}]^+$, m/z 490.0728). The ^1H and ^{13}C NMR spectra showed the signals of two benzylic methylenes ($\delta_{\text{H}} 2.57$, 4H, *m*, H-7 and H-8; $\delta_{\text{C}} 37.6$ and 37.9 , each *t*, C-7 and C-8), a trisubstituted double bond ($\delta_{\text{H}} 6.80$, *s*; H-7'; $\delta_{\text{C}} 127.5$, *d*, C-7', $\delta_{\text{C}} 132.1$, *s*, C-8') and 24 benzene ring carbons, including 11 aromatic protons. From detailed analysis of ^1H - ^1H COSY, ^1H - ^{13}C COSY, HMBC spectra and a NOESY experiment, as well as the comparison with compound **1**, it was obvious that bazzanin B represents the structure of 6',8'-dichloroisoplagiochin C. The linkages of the two bibenzyl units were obtained again from HMBC results. H-5 ($\delta_{\text{H}} 6.33$, *d*, $J = 2.0$ Hz) showed a correlation with carbon C-2' ($\delta_{\text{C}} 127.5$, *s*); and H-3' ($\delta_{\text{H}} 6.86$, *d*, $J = 2.1$ Hz) showed a correlation with carbon C-6 ($\delta_{\text{C}} 125.6$, *s*). Comparable effects were observed between H-13 ($\delta_{\text{H}} 7.09$, *d*, $J = 8.2$ Hz) and C-12' ($\delta_{\text{C}} 128.4$, *s*), as well as between H-13' ($\delta_{\text{H}} 7.18$, *d*, $J = 7.6$ Hz) and C-14 ($\delta_{\text{C}} 126.5$, *s*). The proton H-7', when compared with that of **1**, showed a reduction of its multiplicity in the ^1H NMR spectrum from a doublet ($\delta_{\text{H}} 6.47$, *d*, $J = 12$ Hz) to a singlet ($\delta_{\text{H}} 6.80$). Due to the presence of a $^2J_{\text{CH-}}$ coupling from H-5' ($\delta_{\text{H}} 7.21$, *d*, $J = 2.1$ Hz) to C-6' ($\delta_{\text{C}} 122.0$, *s*) and from H-7' ($\delta_{\text{H}} 6.80$, *s*) to C-8' ($\delta_{\text{C}} 132.1$, *s*) in the long-range correlation spectra and the ^{13}C NMR values of C-6' and C-8' (measured: $\delta_{\text{C}} 122.0$ and 132.1 , calculated: $\delta_{\text{C}} 122.3$ and 132.5), the positions of the chlorine atoms were determined. The suggested existence of two chlorine atoms was also proven by high resolution mass spectrometry, that showed the typical isotope pattern in the $[\text{M}]^+$ peaks (m/z 490:492:494 = 100:74:17) and the subsequent loss of two chlorine atoms (m/z 455 and 420).

Bazzanin C (3)

Compound **3** has the molecular formula $\text{C}_{28}\text{H}_{19}\text{O}_4\text{Cl}_3$. The EI mass spectrum showed the typical isotope pattern of three chlorine atoms in the molecule. The ^1H NMR and ^{13}C NMR spectra of **3** were very similar to those of **2**. However, the proton H-13 in **3**, when compared with that of **2**, showed a reduction of its multiplicity from a doublet ($\delta_{\text{H}} 7.09$, *d*, $J = 8.2$ Hz) to a singlet ($\delta_{\text{H}} 7.25$) and a $^2J_{\text{CH-}}$ coup-

ling to the quaternary carbon C-12 ($\delta_{\text{C}} 118.2$, *s*) in the HMBC spectrum. In the ^{13}C NMR and DEPT spectra of **3**, when compared with those of **2**, the multiplicity of C-12 had changed from *d* to *s*. Its chemical shift ($\delta_{\text{C}} 118.2$) is common for a chlorinated carbon. Therefore, bazzanin C represents the structure of 6',8',12-trichloroisoplagiochin C. This could also be concluded from detailed analysis of ^1H - ^1H COSY, ^1H - ^{13}C COSY, HMBC spectra and a NOESY experiment.

Bazzanin D (4)

The EI high resolution mass spectrum ($[\text{M}]^+$ at m/z 524.0344) was in agreement with the molecular formula $\text{C}_{28}\text{H}_{19}\text{O}_4\text{Cl}_3$ and showed the typical isotope pattern of three chlorine atoms in the molecule. The ^1H and ^{13}C NMR spectra were similar to those of **1**-**3**. In comparison with **2**, the ^1H spectrum of **4** is lacking the signal for H-10' and H-14' displayed a reduction of its multiplicity from a double doublet (in **2**: $\delta_{\text{H}} 6.99$, *dd*, $J = 7.6$, 1.6 Hz) to a doublet (in **4**: $\delta_{\text{H}} 7.04$, *d*, $J = 7.7$ Hz). The ^{13}C NMR of **4** revealed for C-10' the signal of a quaternary carbon ($\delta_{\text{C}} 119.5$, *s*), which had an additional chlorine atom. Thus, bazzanin D represents the structure of 6',8',10'-trichloroisoplagiochin C. The results of ^1H - ^1H COSY, ^1H - ^{13}C COSY, HMBC and NOESY experiments supported this assignment.

Bazzanins E (5) and F (6)

The molecular formula of both compounds was determined to be $\text{C}_{28}\text{H}_{18}\text{O}_4\text{Cl}_4$. The high resolution EI mass spectrum showed the $[\text{M}]^+$ at m/z 557.9968 for compound **5** and the CI mass spectrum at m/z 558 for compound **6**, both with the typical isotope pattern of four chlorine atoms. In addition, there was also the subsequent loss of three chlorine atoms (m/z 523, 488 and 453). The structure of **5** followed immediately from considerations of its ^1H NMR spectrum. In contrast to **1**, H-13 ($\delta_{\text{H}} 7.22$) and H-7' ($\delta_{\text{H}} 6.94$) appeared as singlets, as described for **3**, and H-14' ($\delta_{\text{H}} 7.05$) as a doublet, as found in **4**.

The NMR spectra of bazzanin F (**6**) were very close to those of **2**, except for the resonances of H-10 and H-14, which were missing. These protons were replaced by two chlorine atoms which can be concluded from the multiplicities and chemical shifts of the corresponding carbon atoms ($\delta_{\text{C}} 122.8$, *s*, C-10; $\delta_{\text{C}} 124.2$, *s*, C-14'). Another peculiarity is the splitting of the proton signals of the ethanobridge in the ratio of 1:2:1 ($\delta_{\text{H}} 2.57$, *m*, H-7_a, $\delta_{\text{H}} 2.63$, *m*, H-7_b and H-8_a, $\delta_{\text{H}} 2.85$, *m*, H-8_b) that is attributed to the replacement of the adjacent H-10 by a chlorine atom.

Therefore, the above results indicated **5** to be 6',8',10',12-tetrachloroisoplagiochin C and **6** to be 6',8',10,14'-tetrachloroisoplagiochin C, which was further confirmed by proton-proton and proton-carbon shift correlated 2D experiments.

Bazzanins G (7) and H (8)

Similarities of the two compounds refer to the molecular formula $C_{28}H_{17}O_4Cl_5$ that results from their CI-mass spectra ($[M]^+$ m/z 592) and the chlorination of C-10 that is indicated by the splitting of the 1H NMR signals of the ethanobridge in the ratio 1:2:1 (7: δ_H 2.53, *m*, H-7_a, δ_H 2.65, *m*, H-7_b and H-8_a, δ_H 2.78, *m*, H-8_b; 8: δ_H 2.57, *m*, H-7_a, δ_H 2.64, *m*, H-7_b and H-8_a, δ_H 2.81, *m*, H-8_b). Comparison between the one-dimensional NMR spectra showed that the stilbene part in structure 7 has the same substitution pattern as described for compounds 4 and 5. In the 1H NMR spectrum, ring B of the bibenzyl moiety is represented by the *ortho*-coupled doublet of H-12 (δ_H 6.80, *d*, $J = 8.7$ Hz) and H-13 (δ_H 7.27, *d*, $J = 8.7$ Hz) in accordance with ring B in bazzanin F (6). Ring A bears a chlorine atom at C-2 (δ_C 121.1, *s*). This can be concluded from the NOESY spectrum that shows a correlation between the *meta*-coupled doublet of H-3 (δ_H 7.18, *d*, $J = 2.2$ Hz) and H-5 (δ_H 6.08, *d*, $J = 2.2$ Hz) with the methylene protons H-7 (δ_H 2.53, *m*, H-7_a, δ_H 2.65, *m*, H-7_b) of the ethanobridge.

The NMR spectral data of bazzanin H (8) are in good agreement with those of compound 6. The additional chlorine atom in 8 must be positioned at C-10' (δ_C 121.5, *s*) because of the loss of H-10'. Based on the above spectral evidence, together with the evaluation of 2D-NMR experiments, compounds 7 and 8 are assigned as the pentachlorinated structures 2,6',8',10,10'-pentachloroisoplagiochin C (7) and 6',8',10,10',14'-pentachloroisoplagiochin C (8).

Bazzanin I (9)

Compound 9 represents the highest degree of chlorination within the bazzanines. The CI mass spectrum ($[M]^+$, m/z 626) and the NMR spectral data were in accordance with the molecular formula $C_{28}H_{16}O_4Cl_6$. The 1H and ^{13}C NMR indicated a stilbene partial structure related to 8 (Tables 1 and 2), their spectral data being very much alike. Ring A of the bibenzyl moiety is represented by the two *meta*-coupled doublets of H-3 (δ_H 7.17, *d*, $J = 2.1$ Hz) and H-5 (δ_H 6.01, *d*, $J = 2.1$ Hz) in the 1H NMR spectrum that were first described for 7, while the singlets at 7.01 and 7.23 were attributed to H-10 and H-13, thus revealing the substitution pattern of the B ring. This has already been discussed for compounds 3 and 5. Therefore, the structure 2,6',8',10',12,14'-hexachloroisoplagiochin C, was assigned to 9, together with the trivial name bazzanin I.

Bazzanin J (10)

Compound 10 gave an EI mass spectrum $[M]^+$ at m/z 492, in agreement with a molecular formula of $C_{28}H_{22}O_4Cl_2$. The 1H and ^{13}C NMR spectra showed the signals of four benzylic methylenes (δ_H 2.75, 8H, *m*; δ_C 35.9, 37.7, 37.8, 37.9, each *t*) and 24 benzene

ring carbons, including 10 olefinic methines and 14 quaternary carbons. Comparison of the NMR data from 10 with those of the structures of bazzanins A–I revealed that both compounds only differed in the functionalisation of C-7' and C-8'. In 3, C-7' and C-8' (δ_C 127.4, *d* and 131.7, *s*) formed a trisubstituted double bond bearing a chlorine atom at C-8', whereas in 10, C-7' and C-8' (δ_C 35.9 and 37.7, each *t*) possessed two benzylic methylene groups. This led to the assumption that 10 represents 6',12-dichloroisoplagiochin D, the non-chlorinated derivative of which, isoplagiochin D, is already known from the liverwort, *Plagiochila fruticosa* [7]. On the basis of this evidence and supplementary detailed analysis of 2D NMR spectra (Fig. 3), the molecular structure of 10 was established and given the name bazzanin J.

Bazzanin K (11)

The molecular formula of 11 was determined to be $C_{29}H_{20}O_4Cl_2$ by EI mass spectrometry ($[M]^+$ m/z 502). The 1H and ^{13}C spectra showed the signals of one methoxyl group (δ_H 3.81, 3H, *s*; δ_C 55.8, *q*), with 24 benzene ring carbons, including 10 methines, 14 quaternary carbons and two benzylic methylenes. It was remarkable that the protons of the two methylenes (δ_H 2.25, *ddd*, H-8_a; 2.71, *tt*, H-7_b; 2.95, *tt*, H-8_b; 3.38, *ddd*, H-7_a) showed distinguished signals, quite unusual for *bis*bibenzyls described thus far. This allowed the conclusion that the methylene protons were enclosed in a relatively rigid skeleton. 1H – 1H , 1H – ^{13}C COSY and HMBC (Fig. 2) revealed for 11 a bibenzyl and a phenanthrene subunit, of which the bibenzyl moiety bore two hydroxyl groups at C-1 (δ_C 152.1, *s*) and C-11 (δ_C 151.4, *s*), and a chlorine atom at C-14 (δ_C 126.4, *s*) and the phenanthrene moiety, a hydroxyl group at C-1' (δ_C 146.9, *s*), a methoxyl group at C-11' (δ_C 155.9, *s*) and a chlorine atom at C-6' (δ_C 120.3, *s*).

Comparison between the 1H NMR data of the phenanthrene moiety with those published in literature [10], the chemical shift of H-13' in the 1H NMR spectrum (δ_H 6.01, *s*) was quite unusual. The shift of the corresponding H-5 in 2-hydroxy-3,7-dimethoxyphenanthrene [10] is situated at lower field (δ_H 8.41, *d*, $J = 8.6$ Hz). A possible explanation was that H-13' was exposed to the anisotropic effect of ring A (Fig. 3). The linkages of the subunits (phenanthrene with bibenzyl) were also obtained from HMBC results (Fig. 2). H-13' (δ_H 6.01, *s*) and H-12 (δ_H 6.73, *d*, $J = 8.5$ Hz) showed a correlation with carbon C-10 (δ_C 127.7, *s*) of the bibenzyl and H-5 (δ_H 6.86, *d*, $J = 2.1$ Hz) correlated with C-2' (δ_C 120.9, *s*) of the phenanthrene moiety. The above data proved the structure of 11, which we named bazzanin K.

Halogenated natural products are mainly known from marine organisms, fungi and higher plants [11]. Only one halogenated structure has been isolated from a liverwort so far, the mono chlorinated diterpenoid from *Makinoa crispata* [12].

Table 1. ^1H NMR spectral data for compounds 1–11 (CDCl_3)

H	1	2	3	4	5	6	7	8	9	10	11
H-2	6.74 d (8.1)	6.73 d (8.1)	6.78 d (8.1)	6.82 d (8.1)	6.83 d (8.1)	6.77 d (8.1)	—	6.79 d (8.0)	—	6.79 d (8.1)	6.85 d (8.2)
H-3	6.98 dd (8.0, 2.0)	6.95 dd (8.1, 2.0)	6.99 dd (8.1, 2.0)	7.03 dd (8.1, 2.0)	7.03 dd (8.1, 2.1)	7.03 dd (8.1, 2.2)	7.18 d (2.2)	7.04 dd (8.0, 2.2)	7.17 d (2.1)	7.00 dd (8.1, 2.2)	6.75 dd (8.2, 2.1)
H-5	6.50 d (2.0)	6.33 d (2.1)	6.29 d (2.0)	6.16 d (2.0)	6.10 d (2.1)	6.30 d (2.2)	6.08 d (2.2)	6.18 d (2.2)	6.01 d (2.1)	6.25 d (2.2)	6.86 d (2.1)
H-7	2.59 m (2H)	2.57 m (2H)	2.57 m (2H)	2.55 m (2H)	2.58 m (2H)	2.57 m (2H)	2.53 m; 2.63 m	2.57 m; 2.64 m	2.43 dd; 2.56 dd	2.75 m (2H)	3.38 ddd, 2.71 t
H-8	2.59 m (2H)	2.57 m (2H)	2.57 m (2H)	2.55 m (2H)	2.58 m (2H)	2.63 m; 2.85 m	2.65 m; 2.78 m	2.64 m; 2.81 m	2.61 dd; 2.76 dd	2.75 m (2H)	2.25 ddd, 2.95 t
H-10	6.83 d (2.0)	6.82 d (2.5) s	7.03 s	6.84 d (2.6)	7.02 s	—	—	—	7.01 s	7.04 s	—
H-12	6.76 dd (7.9, 2.0)	6.75 dd (8.2, 2.5)	—	6.78 dd (8.3, 2.6)	—	6.79 d (8.7)	6.80 d (8.7)	6.78 d (8.7)	—	—	6.73 d (8.5)
H-13	7.11 d (7.9)	7.09 d (8.2)	7.25 s	7.12 d (8.3)	7.22 s	7.25 d (8.7)	7.27 d (8.7)	7.27 d (8.7)	7.23 s	7.22 s	7.28 d (8.5)
H-3'	7.12 d (2.2)	6.86 d (2.1)	6.84 d (2.0)	6.75 d (2.1)	6.72 d (2.1)	6.82 d (2.2)	6.68 d (2.2)	6.75 d (2.2)	6.63 d (2.2)	6.37 d (2.1)	—
H-5'	7.25 d (2.2)	7.21 d (2.1)	7.24 d (2.0)	7.27 d (2.1)	7.27 d (2.1)	7.23 d (2.2)	7.26 d (2.2)	7.26 d (2.2)	7.31 d (2.2)	7.23 d (2.1)	7.93 s
H-7'	6.47 d (12.0)	6.80 s	6.82 s	6.94 s	6.94 s	6.90 s	6.93 s	7.01 s	7.03 s	2.75 m (2H)	7.62 d (8.8)
H-8'	6.69 d (12.0)	—	—	—	—	—	—	—	—	2.75 m (2H)	7.57 d (8.8)
H-10'	6.88 d (1.6)	7.02 d (1.6)	7.03 br s	—	—	7.03 br s	—	—	—	6.80 d (1.6)	7.13 s
H-13'	7.13 d (7.6)	7.18 d (7.6)	7.20 d (7.6)	7.20 d (7.7)	7.20 d (7.7)	7.27 br s	7.17 d (7.9)	7.27 s	7.28 s	7.07 d (7.6)	6.01 s
H-14'	6.87 dd (7.6, 1.6)	6.99 dd (7.6, 1.6)	7.04 dd (7.6, 1.6)	7.04 d (7.7)	7.05 d (7.7)	—	7.00 d (7.9)	—	—	6.70 dd (7.6, 1.6)	—
H-15'	—	—	—	—	—	—	—	—	—	—	3.81 s (3H)

Coupling constants (J in Hz) in parentheses.

Table 2. ^{13}C NMR spectral data for compounds 1–11 (CDCl_3)

Carbon	1	2	3	4	5	6	7	8	9	10	11
C-1	150.0 <i>s</i>	150.3 <i>s</i>	151.0 <i>s</i>	151.0 <i>s</i>	151.0 <i>s</i>	150.4 <i>s</i>	145.7 <i>s</i>	151.0 <i>s</i>	145.8 <i>s</i>	151.3 <i>s</i>	152.1 <i>s</i>
C-2	114.9 <i>d</i>	116.4 <i>d</i>	116.2 <i>d</i>	117.5 <i>d</i>	117.6 <i>d</i>	116.1 <i>d</i>	121.1 <i>s</i>	117.4 <i>d</i>	121.2 <i>s</i>	117.0 <i>d</i>	118.1 <i>d</i>
C-3	128.0 <i>d</i>	128.5 <i>d</i>	128.7 <i>d</i>	128.9 <i>d</i>	128.9 <i>d</i>	128.7 <i>d</i>	128.6 <i>d</i>	128.4 <i>d</i>	128.3 <i>d</i>	128.5 <i>d</i>	132.0 <i>d</i>
C-4	135.6 <i>s</i>	135.6 <i>s</i>	135.4 <i>s</i>	136.0 <i>s</i>	135.7 <i>s</i>	135.4 <i>s</i>	139.5 <i>s</i>	135.6 <i>s</i>	136.4 <i>s</i>	135.0 <i>s</i>	134.9 <i>s</i>
C-5	133.7 <i>d</i>	133.6 <i>d</i>	133.3 <i>d</i>	132.8 <i>d</i>	132.8 <i>d</i>	133.2 <i>d</i>	131.9 <i>d</i>	132.7 <i>d</i>	131.7 <i>d</i>	133.5 <i>d</i>	134.3 <i>d</i>
C-6	125.6 <i>s</i>	125.6 <i>s</i>	125.5 <i>s</i>	125.4 <i>s</i>	125.4 <i>s</i>	125.5 <i>s</i>	126.5 <i>s</i>	125.4 <i>s</i>	126.4 <i>s</i>	125.9 <i>s</i>	124.1 <i>s</i>
C-7	37.3 <i>t</i>	37.6 <i>t</i>	37.4 <i>t</i>	37.7 <i>t</i>	37.6 <i>t</i>	34.5 <i>t</i>	34.2 <i>t</i>	34.4 <i>t</i>	37.3 <i>t</i>	37.8 <i>t</i>	32.1 <i>t</i>
C-8	37.9 <i>t</i>	37.9 <i>t</i>	37.6 <i>t</i>	38.0 <i>t</i>	37.6 <i>t</i>	36.0 <i>t</i>	35.9 <i>t</i>	36.1 <i>t</i>	37.4 <i>t</i>	37.9 <i>t</i>	32.8 <i>t</i>
C-9	143.5 <i>s</i>	144.0 <i>s</i>	143.2 <i>s</i>	143.5 <i>s</i>	142.4 <i>s</i>	140.3 <i>s</i>	138.7 <i>s</i>	139.9 <i>s</i>	141.7 <i>s</i>	143.5 <i>s</i>	137.8 <i>s</i>
C-10	115.8 <i>d</i>	116.3 <i>d</i>	117.2 <i>d</i>	116.2 <i>d</i>	116.8 <i>d</i>	122.8 <i>s</i>	123.6 <i>s</i>	122.7 <i>s</i>	116.9 <i>d</i>	117.0 <i>d</i>	127.7 <i>s</i>
C-11	156.5 <i>s</i>	156.7 <i>s</i>	151.9 <i>s</i>	156.0 <i>s</i>	151.5 <i>s</i>	153.2 <i>s</i>	152.6 <i>s</i>	152.5 <i>s</i>	151.8 <i>s</i>	151.6 <i>s</i>	151.4 <i>s</i>
C-12	113.0 <i>d</i>	113.8 <i>d</i>	118.2 <i>s</i>	113.6 <i>d</i>	117.7 <i>s</i>	115.1 <i>d</i>	115.2 <i>d</i>	115.3 <i>d</i>	118.0 <i>s</i>	118.0 <i>s</i>	114.1 <i>d</i>
C-13	131.6 <i>d</i>	132.1 <i>d</i>	131.5 <i>s</i>	131.8 <i>d</i>	130.7 <i>s</i>	130.7 <i>d</i>	130.6 <i>d</i>	130.9 <i>d</i>	130.7 <i>d</i>	131.5 <i>d</i>	129.9 <i>d</i>
C-14	127.7 <i>s</i>	126.5 <i>s</i>	129.1 <i>s</i>	127.7 <i>s</i>	128.9 <i>s</i>	125.5 <i>s</i>	125.5 <i>s</i>	125.9 <i>s</i>	127.8 <i>s</i>	128.4 <i>s</i>	126.4 <i>s</i>
C-1'	148.3 <i>s</i>	148.1 <i>s</i>	147.0 <i>s</i>	147.0 <i>s</i>	147.0 <i>s</i>	148.8 <i>s</i>	148.5 <i>s</i>	147.9 <i>s</i>	148.5 <i>s</i>	145.2 <i>s</i>	146.9 <i>s</i>
C-2'	127.5 <i>s</i>	127.5 <i>s</i>	127.8 <i>s</i>	127.0 <i>s</i>	127.0 <i>s</i>	127.9 <i>s</i>	126.7 <i>s</i>	126.5 <i>s</i>	126.6 <i>s</i>	125.9 <i>s</i>	120.9 <i>s</i>
C-3'	131.4 <i>d</i>	130.9 <i>d</i>	131.5 <i>d</i>	130.0 <i>d</i>	130.0 <i>d</i>	129.1 <i>d</i>	129.2 <i>d</i>	127.6 <i>d</i>	128.2 <i>d</i>	133.1 <i>d</i>	130.9 <i>s</i>
C-4'	129.7 <i>s</i>	128.7 <i>s</i>	129.4 <i>s</i>	129.1 <i>s</i>	129.6 <i>s</i>	129.0 <i>s</i>	128.1 <i>s</i>	128.4 <i>s</i>	128.3 <i>s</i>	135.1 <i>s</i>	128.4 <i>s</i>
C-5'	129.9 <i>d</i>	129.8 <i>d</i>	129.4 <i>d</i>	129.4 <i>d</i>	129.6 <i>d</i>	130.0 <i>d</i>	130.5 <i>d</i>	129.2 <i>d</i>	130.4 <i>d</i>	128.3 <i>d</i>	129.0 <i>d</i>
C-6'	122.1 <i>s</i>	122.0 <i>s</i>	122.0 <i>s</i>	121.2 <i>s</i>	121.2 <i>s</i>	122.9 <i>s</i>	122.5 <i>s</i>	122.2 <i>s</i>	122.6 <i>s</i>	120.1 <i>s</i>	120.3 <i>s</i>
C-7'	128.6 <i>d</i>	127.5 <i>d</i>	127.4 <i>d</i>	129.4 <i>d</i>	129.6 <i>d</i>	129.6 <i>d</i>	129.9 <i>d</i>	131.6 <i>d</i>	131.2 <i>d</i>	35.9 <i>t</i>	127.4 <i>d</i>
C-8'	129.8 <i>d</i>	132.1 <i>s</i>	131.7 <i>s</i>	129.4 <i>s</i>	129.1 <i>s</i>	127.9 <i>s</i>	128.3 <i>s</i>	125.9 <i>s</i>	126.1 <i>s</i>	37.7 <i>t</i>	125.7 <i>d</i>
C-9'	139.4 <i>s</i>	139.5 <i>s</i>	140.1 <i>s</i>	137.3 <i>s</i>	137.6 <i>s</i>	138.7 <i>s</i>	136.6 <i>s</i>	136.7 <i>s</i>	135.8 <i>s</i>	142.9 <i>s</i>	136.0 <i>s</i>
C-10'	115.0 <i>d</i>	116.0 <i>d</i>	117.1 <i>d</i>	119.5 <i>s</i>	119.7 <i>s</i>	118.4 <i>d</i>	120.4 <i>s</i>	121.5 <i>s</i>	121.2 <i>s</i>	116.5 <i>d</i>	107.0 <i>d</i>
C-11'	154.1 <i>s</i>	154.0 <i>s</i>	153.8 <i>s</i>	150.3 <i>s</i>	150.2 <i>s</i>	153.9 <i>s</i>	150.8 <i>s</i>	149.5 <i>s</i>	148.9 <i>s</i>	153.1 <i>s</i>	155.9 <i>s</i>
C-12'	127.0 <i>s</i>	128.4 <i>s</i>	127.5 <i>s</i>	130.1 <i>s</i>	129.1 <i>s</i>	125.0 <i>s</i>	128.1 <i>s</i>	129.2 <i>s</i>	129.7 <i>s</i>	124.4 <i>s</i>	121.0 <i>s</i>
C-13'	131.7 <i>d</i>	132.1 <i>d</i>	131.7 <i>d</i>	130.7 <i>d</i>	130.7 <i>d</i>	133.2 <i>d</i>	131.0 <i>d</i>	131.6 <i>d</i>	131.0 <i>s</i>	130.7 <i>d</i>	134.6 <i>d</i>
C-14'	119.9 <i>d</i>	120.8 <i>d</i>	121.2 <i>d</i>	121.8 <i>d</i>	122.0 <i>d</i>	124.2 <i>d</i>	120.4 <i>d</i>	125.1 <i>s</i>	125.1 <i>s</i>	122.4 <i>d</i>	122.7 <i>s</i>
C-15'	—	—	—	—	—	—	—	—	—	—	55.8 <i>q</i>

Assignments confirmed by 2D NMR ^1H – ^{13}C -COSY and HMBC.

EXPERIMENTAL

General. Solvents used for spectral measurements: CDCl_3 ^1H NMR: 400 MHz, ^{13}C NMR: 100 MHz for 1D-spectra, 500 and 125 MHz for 2D-spectra, respectively. Chemical shifts are given in δ relative to CHCl_3 at δ_{H} 7.24 or CDCl_3 at δ_{C} 77.0. MeOH (UV, rotation). IR: KBr. EI-MS (direct inlet) 70 eV, CI-MS and DCI-MS.

Plant material. *Bazzania trilobata* (L.) S.F. Gray was collected in Weißkirchen, Saarland, Germany, during March 1994. The plant was identified by Prof. R. Mues at the Institute of 'Botanik der Universität des Saarlands', Saarbrücken, Germany, and a herbarium specimen with the voucher number 40 is deposited at 'Pharmakognosie und Analytische Phytochemie, Universität des Saarlands', Saarbrücken, Germany.

Extraction and isolation. Air-dried and powdered plant material (930 g) was extracted with Et_2O to remove non-polar compounds, followed by MeOH. The evapd MeOH extract was distributed between EtOAc and H_2O . The organic layer was evapd *in vacuo* and chromatographed on Sephadex LH-20 using MeOH – CH_2Cl_2 (4:1) as eluent to yield 5 frs. Fr. 5 was

chromatographed on diol-modified silica gel *via* VLC using an *n*-hexane– EtOAc – MeOH gradient yielding 8 frs 5.1–5.8. Further purification of fr. 5.3 by HPLC (LiChrospher Diol, 5 μm , *n*-hexane– EtOAc , 11:9) afforded bazzanin K (11) (6.2 mg), bazzanin G (7) (6.1 mg), bazzanin F (6) (2.0 mg), as well as a mixt. of 8 and 9. From this mixt., 2.0 mg bazzanin H (8) and 2.5 mg bazzanin I (9) were isolated by HPLC (LiChrospher Diol, 5 μm , *n*-hexane–tert. butylmethylether, 1:3), following by HPLC (Spherisorb CN, 5 μm , *n*-hexane– EtOAc , 3.3:0.7). Sepn of fr. 5.4 using HPLC (Spherisorb ODS 1, 5 μm , MeOH – H_2O , 7:3+1% HCO_2H), yielded bazzanin A (1) (3.6 mg), a mixt. of 2, 4 and 10, as well as a mixt. of 3 and 5. The mixt. of 2, 4 and 10 was further sep'd using HPLC (Spherisorb ODS 1, 5 μm , MeCN – H_2O , 5.5:4.5+1% HCO_2H) to yield bazzanin D (4) (8.7 mg), bazzanin J (10) (4.8 mg) and bazzanin B (2) (23.3 mg) by subsequent HPLC (Spherisorb CN, 5 μm , *n*-hexane– EtOAc , 4:1). The remaining mixt. (3 and 5) was chromatographed on HPLC (Spherisorb CN, 5 μm , *n*-hexane– EtOAc , 4:1) yielding 10.6 mg of bazzanin C (3) and 10.0 mg of bazzanin E (5).

Compound 1. $[\alpha]_{\text{D}}^{20} + 53.3^\circ$ (MeOH ; *c* 0.3). IR $\nu_{\text{cm}^{-1}}$: 3300, 2910, 1610, 1450, 1400, 1300. UV λ_{max}

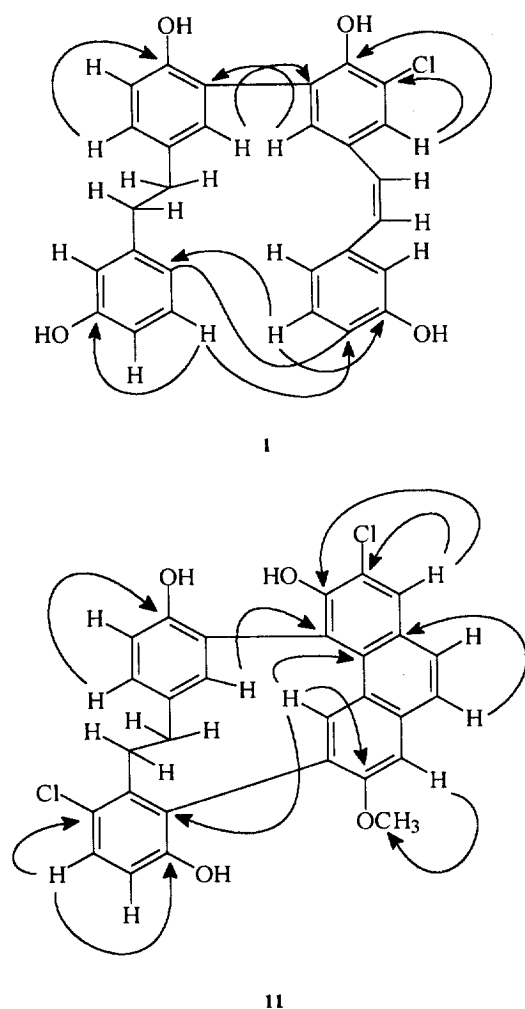


Fig. 3. Significant NOESY correlations of compounds 10 and 11.

nm: 250, 289; $\lambda_{\min}$: 274. ^1H NMR: Table 1. ^{13}C NMR: Table 2. DCIMS: $[\text{M}]^+$ m/z 456, 456:458 (100:32).

Compound 2. $[\alpha]_{\text{D}}^{20} + 66.0^\circ$ (MeOH; c 1.0). IR ν cm^{-1} : 3350, 2910, 1610, 1480, 1410, 1300. UV $\lambda_{\max}$ nm: 255, 297; $\lambda_{\min}$: 274. ^1H NMR: Table 1. ^{13}C NMR: Table 2. HR EIMS m/z (rel. int.): 490.0728 $[\text{M}]^+$, 490:492:494 (100:74:17), 455 $[\text{M}-35]^+$, 420 $[\text{M}-70]^+$.

Compound 3. $[\alpha]_{\text{D}}^{20} + 61.1^\circ$ (MeOH; c 1.0). IR ν cm^{-1} : 3400, 2900, 1600, 1480, 1400, 1280. UV $\lambda_{\max}$ nm: 252, 291; $\lambda_{\min}$: 274. ^1H NMR: Table 1. ^{13}C NMR: Table 2. HR EIMS m/z (rel. int.): 524.0345 $[\text{M}]^+$, 524:526:528:530 (100:97:33:10), 489 $[\text{M}-35]^+$, 454 $[\text{M}-70]^+$.

Compound 4. $[\alpha]_{\text{D}}^{20} + 74.4^\circ$ (MeOH; c 0.8). IR ν cm^{-1} : 3350, 2900, 1600, 1480, 1400, 1280. UV $\lambda_{\max}$ nm: 250, 289; $\lambda_{\min}$: 274. ^1H NMR: Table 1. ^{13}C NMR: Table 2. HR EIMS m/z (rel. int.): 524.0344 $[\text{M}]^+$, 524:526:528:530 (100:97:33:10), 489 $[\text{M}-35]^+$, 454 $[\text{M}-70]^+$.

Compound 5. $[\alpha]_{\text{D}}^{20} + 190.0^\circ$ (MeOH; c 1.0). IR ν cm^{-1} : 3400, 2910, 1610, 1490, 1410, 1300. UV $\lambda_{\max}$

nm: 252, 290; $\lambda_{\min}$: 274. ^1H NMR: Table 1. ^{13}C NMR: Table 2. HR EIMS m/z (rel. int.): 557.9968 $[\text{M}]^+$, 558:560:562:564:566 (81:100:53:16:3), 523 $[\text{M}-35]^+$, 488 $[\text{M}-70]^+$, 453 $[\text{M}-105]^+$.

Compound 6. $[\alpha]_{\text{D}}^{20} + 125.0^\circ$ (MeOH; c 0.2). IR ν cm^{-1} : 3400, 2910, 1610, 1490, 1410, 1300. UV $\lambda_{\max}$ nm: 255, 296; $\lambda_{\min}$: 273. ^1H NMR: Table 1. ^{13}C NMR: Table 2. CIMS m/z (rel. int.): 558 $[\text{M}]^+$, 558:560:562:564:566 (81:100:53:16:3), 523 $[\text{M}-35]^+$, 488 $[\text{M}-70]^+$, 453 $[\text{M}-105]^+$.

Compound 7. $[\alpha]_{\text{D}}^{20} + 40.0^\circ$ (MeOH; c 0.6). IR ν cm^{-1} : 3450, 2910, 1610, 1460, 1410, 1300. UV $\lambda_{\max}$ nm: 255, 293; $\lambda_{\min}$: 274. ^1H NMR: Table 1. ^{13}C NMR: Table 2. CIMS m/z (rel. int.): 592 $[\text{M}]^+$, 592:594:596 (63:100:64).

Compound 8. $[\alpha]_{\text{D}}^{20} + 130.0^\circ$ (MeOH; c 0.2). IR ν cm^{-1} : 3400, 2910, 1610, 1460, 1400, 1300. UV $\lambda_{\max}$ nm: 252, 293; $\lambda_{\min}$: 276. ^1H NMR: Table 1. ^{13}C NMR: Table 2. CIMS m/z (rel. int.): 592 $[\text{M}]^+$, 592:594:596 (63:100:64).

Compound 9. $[\alpha]_{\text{D}}^{20} + 60.0^\circ$ (MeOH; c 0.2). IR ν cm^{-1} : 3400, 2900, 1610, 1480, 1400, 1280. UV $\lambda_{\max}$ nm: 252, 296; $\lambda_{\min}$: 276. ^1H NMR: Table 1. ^{13}C NMR: Table 2. CIMS m/z (rel. int.): 626 $[\text{M}]^+$, 626:628:630 (51:100:89).

Compound 10. $[\alpha]_{\text{D}}^{20} + 0.0^\circ$ (MeOH; c 0.4). IR ν cm^{-1} : 3400, 2910, 1610, 1490, 1400, 1300. UV $\lambda_{\max}$ nm: 252, 287; $\lambda_{\min}$: 271. ^1H NMR: Table 1. ^{13}C NMR: Table 2. HR EIMS m/z (rel. int.): 492.0898 $[\text{M}]^+$, 492:494:496 (100:70:14), 245.0369 $[\text{M}-\text{C}_{14}\text{H}_{12}\text{O}_2\text{Cl}]^+$.

Compound 11. $[\alpha]_{\text{D}}^{20} + 180.0^\circ$ (MeOH; c 0.6). IR ν cm^{-1} : 3400, 2900, 1620, 1480, 1450. UV $\lambda_{\max}$ nm: 246, 296; $\lambda_{\min}$: 276. ^1H NMR: Table 1. ^{13}C NMR: Table 2. EIMS m/z (rel. int.): 502 $[\text{M}]^+$, 502:504:506 (100:70:14).

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