Pergamon

PII: S0031-9422(96)00506-7

Phytochemistry, Vol. 43, No. 6, pp. 1379–1384, 1996

0031-9422/96 $15.00 + 0.00

ALKALOIDS FROM *BRUNSVIGIA ORIENTALIS*

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(*Received* 27 *March* 1996)

Key Word Index—*Brunsvigia orientalis*; Amaryllidaceae; bulbs; alkaloids; lycorine; crinine; buphanisine; buphanidrine; epibuphanisine; undulatine; crinamidine; crinamine; 6-hydroxycrinamine; 1-epibowdensine; 1-epidemethoxybowdensine; 1-epideacetylbowdensine.

Abstract—Twelve alkaloids have been isolated from bulbs of *Brunsvigia orientalis*. 1-Epibowdensine, 1-epidemethoxybowdensine and 1-epidecacetylbowdensine are reported here for the first time. The structure and stereochemistry of these new alkaloids have been determined by physical and spectroscopic methods. The ^{1}H and ^{13}C NMR spectra of 6-hydroxycrinamine (both epimers) and crinamidine were completely assigned by means of 2D NMR techniques. Copyright © 1996 Elsevier Science Ltd

INTRODUCTION

Brunsvigia orientalis is an endemic Amaryllidaceae species from southern Africa, widely distributed in the southern and southwestern Cape [1]. In the present study, we report the isolation and characterization of 12 alkaloids from the bulbs of this hitherto unstudied plant species. Undulatine (**2**), crinamine (**4**) and the new alkaloid, 1-epibowdensine (**5**), were found to be the principal constituents. According to the literature, compound **2** was described as an active antineoplastic agent from *Amaryllis belladonna* bulbs [2]. In turn, compound **4** was the principal antibacterial constituent of the bulbs of *Crinum jagus* [3], possessing strong cytotoxic and moderate antimalarial activities [4]. Compound **5**, as well as 1-epidemethoxybowdensine (**6**) and 1-epideacetylbowdensine (**7**), were the first natural β-5,10b-ethanophenanthridine alkaloids having the C-1 substituent in the equatorial orientation. It is noteworthy that, just as in *B. josephinae* [5, 6], the majority of alkaloids from *B. orientalis* belong to the 5,10b-ethanophenanthridines; many of them have a methoxyl group at the C-7 position.

RESULTS AND DISCUSSION

The absolute configurations of alkaloids with a 5,10b-ethano bridge were determined from circular dichroism (CD) curves. In this way, the molecular ellipticity of crinamidine (**1**), **2**, **5**–**7**, crinine, buphanisine and buphanidrine showed CD curves which were similar qualitatively to those of β-5, 10b-ethanophenanthridine alkaloids with a maximum around 250 nm and, in turn, the CD curves of 6-hydroxycrinamine (**3a** and **3b**), **4** and epibuphanisine were similar to those of α-5,10b-ethanophenanthridines with a minimum around 250 nm [7, 8].

Compound **1**, $C_{17}H_{19}NO_5$, characterized as crinamidine, gave an EI mass spectrum with a base peak at m/z $[M-29]^+$ and exhibited the typical fragmentation pattern for structures with an epoxide ring [9]. The ^{1}H NMR spectrum was completely assigned, providing additional information with respect to a previously reported paper [10]. The spectrum was similar to that of **2** [6], apart from the absence of the singlet attributable to a methoxyl group. The small coupling constants between H-1 and H-2 ($J = 4.0$ Hz), H-2 and H-3 ($J = 2.5$ Hz) and between H-3 and H-4β ($J = 3.0$ Hz), together with the additional long-range coupling of H-2 with H-4α (W-mechanism), allowed us to assign the configurations of the epoxide ring and the hydroxyl group at the C-3 position. The aromatic singlet proton was assigned to the C-10 position, because of the three-bond HMBC correlations with C-6a, as well as with C-10b and C-8, and this was corroborated by the spatial proximity (ROESY [11] experiment) between H-10 and H-1. Thus, it could be inferred that the position of the methoxyl group was at C-7. The ^{13}C spectrum (Table 1) is reported for the first time and all resonances have been unambiguously confirmed by means of HMQC [12] and HMBC [13] experiments. The pronounced highfield shift of the C-1 and C-2, signals, with respect to the corresponding

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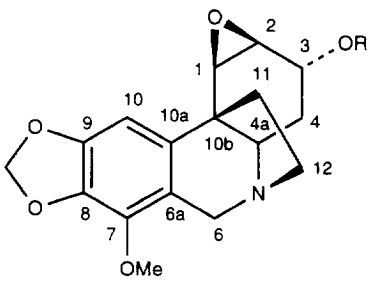

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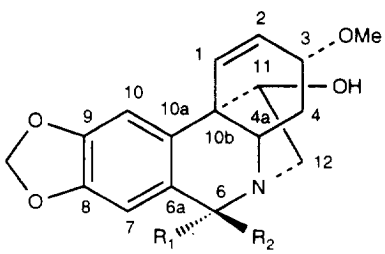
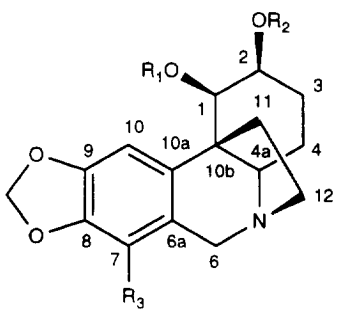
2: R=Me



3a: R_1=H, R_2=OH
3b: R_1=OH, R_2=H
4: R_1=R_2=H



5: R_1=R_2=Ac, R_3=OMe
6: R_1=R_2=Ac, R_3=H
7: R_1=R_2=H, R_3=OMe

signals in the 1,2-unsaturated alkaloids in this series, was consistent with an 1,2-oxiran ring; substitution of the methoxyl group at the C-3 position by an hydroxyl group induced a pronounced shielding effect on C-3 and a deshielding effect on the β-carbons, C-2 and C-4, with respect to **2** [6].

6-Hydroxycrinamine, $C_{17}H_{19}NO_5$, recrystallized as needles from acetone was homogeneous chromatographically but the signals in both ^{1}H and ^{13}C NMR spectra were rather complex, suggesting that it was a 2:1 mixture of two epimers (**3a** and **3b**) in the C-6 position. The EI mass spectrum showed a typical fragmentation pattern of 1,2-unsaturated alkaloids of the crinine series bearing a hydroxyl substituent at C-11 [14]. In this group, the loss of methanol (peak at *m/z* 285) is favoured when both the ethano bridge and the methoxyl group at the C-3 position are on the same side of the molecule and, in the case of derivatives bearing a 6-hydroxyl substituent, ion $[M\text{-methanol}]^+$ very easily loses a hydroxyl radical leading to the base peak (*m/z* 268), which is consistent with 6-hydroxycrinamine data [14]. The ^{1}H NMR spectrum reported in the literature is incomplete [15] and all ^{1}H resonances of both epimers were therefore unambiguously assigned (Table 2). In both, the small coupling constant between H-2 and H-3, the large one between H-4α and H-3, and finally the NOE contour correlation between H-3 and H-4a, were also indicative of a *cis*-relationship between the C-3 pseudoequatorial substituent and the 5,10b-ethano bridge. The deshielding effect on H-11, in relation to the reported data for alkaloids with no bridge substituent in this series [16, 17], as well as the NOE effect between H-10 and H-11 and the long range W-coupling between H-11 and H-4a, were consistent with a C-11 hydroxyl substituent at the *exo*-position. The epimer **3a** showed the benzylic proton H-6α as a singlet at δ 5.01 and spatial proximity between H-6 and H-12 *endo* was observed. In the **3b** spectrum, the proton H-6β was observed at lower fields (δ 5.59) and a NOE contour correlation between H-6β and H-4a was established, confirming the assignation of the hydroxyl group at C-6 in both epimers. The ^{13}C assignments (Table 1), reported for the first time, were confirmed by HMQC and HMBC experiments. The pronounced deshielding effect on C-11 and C-6 of both epimers, observed as doublets, was also consistent with the presence of hydroxyl substituents. In both structures, **3a** and **3b**, the carbon singlet C-9 was assigned at lower fields than C-8 because of its three-bond correlation with the methine proton H-7. The quaternary carbons C-6a and C-10a were ascribed by means of their correlations with the methine protons H-10 and H-7, respectively. Finally, the singlets at δ 50.4 and 50.8 were assigned to C-10b of **3a** and **3b**, respectiely, taking into account their three-bond connectivities with H-2, H-4 and H-10.

Compound **5**, $C_{21}H_{25}HO_7$, as well as its 7-demethoxyl derivative, compound **6**, $C_{20}H_{23}NO_6$, were isolated for the first time from a natural source. Their EI mass spectra displayed a similar fragmentation pattern, with a parent peak at *m/z* 403 and 373, respectively, and important fragments at *m/z* $[M\text{-}59]^+$, $[M\text{-}119]^+$, $[M\text{-}131]^+$, $[M\text{-}149]^+$ and $[M\text{-}171]^+$, which are characteristic of 1,2-disubstituted crinamine alkaloids [18]. Compound **5** showed an additional ion at *m/z* 314, associated with the loss of both the methoxyl and one acetoxy group. The peaks at *m/z* $[M\text{-}59]^+$ and $[M\text{-}119]^+$ were in agreement with the loss of one or two vicinal acetoxy groups. Their ^{1}H NMR spectra (Table 3) were very close and only the absence of a methoxyl group in **6** was noteworthy. The methoxyl group of **5** was assigned to the C-7 position because of

Table 1. ^{13}C NMR chemical shift assignments of compounds **1–7**

C	1	2	3a	3b	4	5	6	7
1	53.8 *d*	53.9 *d*	136.4 *d*	136.2 *d*	136.8 *d*	74.0 *d*	74.0 *d*	73.0 *d*
2	56.4 *d*	55.1 *d*	123.0 *d*	123.2 *d*	123.6 *d*	68.2 *d*	68.3 *d*	69.7 *d*
3	65.5 *d*	74.8 *d*	75.9 *d*	75.6 *d*	76.0 *d*	26.3 *t*	26.4 *t*	28.9 *t*
4	29.7 *t*	25.2 *t*	29.4 *t*	29.4 *t*	30.1 *t*	21.0 *t*	21.3 *t*	20.4 *t*
4a	61.0 *d*	61.2 *d*	59.5 *d*	64.8 *d*	66.1 *d*	68.1 *d*	68.5 *d*	67.6 *d*
6	58.6 *t*	58.6 *t*	88.0 *d*	85.5 *d*	63.5 *t*	58.3 *t*	62.2 *t*	58.2 *t*
6a	117.6 *s*	117.8 *s*	127.3 *s*	128.8 *s*	126.6 *s*	116.9 *s*	125.8 *s*	116.5 *s*
7	141.1 *s*	140.9 *s*	109.5 *d*	108.3 *d*	106.8 *d*	140.3 *s*	106.4 *d*	140.0 *s*
8	133.4 *s*	133.3 *s*	146.5 *s*	146.7 *s*	146.1 *s*	133.4 *s*	146.0 *s*	133.3 *s*
9	148.1 *s*	147.9 *s*	147.8 *s*	147.5 *s*	146.4 *s*	148.0 *s*	146.2 *s*	148.0 *s*
10	96.4 *d*	96.3 *d*	102.8 *d*	102.7 *d*	103.1 *d*	97.3 *d*	103.6 *d*	99.5 *d*
10a	138.7 *s*	138.9 *s*	135.8 *s*	134.6 *s*	135.5 *s*	140.9 *s*	140.0 *s*	142.1 *s*
10b	41.6 *s*	41.4 *s*	50.4 *s*	50.8 *s*	50.2 *s*	47.0 *s*	47.2 *s*	49.3 *s*
11	39.2 *t*	39.2 *t*	78.1 *d*	79.0 *d*	80.0 *d*	37.2 *t*	37.4 *t*	36.4 *t*
12	52.5 *t*	52.5 *t*	57.7 *t*	51.8 *t*	61.2 *t*	52.2 *t*	52.2 *t*	51.7 *t*
-OCH_2O-	100.7 *t*	100.5 *t*	101.1 *t*	101.1 *t*	100.7 *t*	100.5 *t*	100.8 *t*	100.4 *t*
3-OMe		57.5 *q*	55.9 *q*	55.9 *q*	55.6 *q*			
7-OMe	59.1 *q*	59.0 *q*				59.0 *q*		59.0 *q*
1-OAc						21.2 *q*	21.1 *q*	
						170.0 *s*	170.0 *s*	
2-OAc						21.2 *q*	21.2 *q*	
						170.4 *s*	170.4 *s*	

the three-bond HMBC correlations between H-10 and C-6a, as well as with both C-10b and C-8, and between the H-6 protons and C-7, and because of the observed NOE between H-10 and H-1.

Compound **6** showed two *para*-positioned aryl protons, which were consistent with their multiplicity. Both alkaloids have two acetoxy groups at C-1 and C-2; a deshielding effect on H-1 and H-2 was observed. A ROESY experiment allowed us to establish the axial orientation of H-1 by spatial proximity with H-10, as well as with H-3ax. The magnitude of the coupling constant between H-1 and H-2 and between H-2 and H-3ax led us to assign the equatorial disposition for H-2. Consequently, the acetoxy substituents on C-1 and C-2 should be assigned to the equatorial and axial disposition, respectively. The large vicinal coupling constants between H-4ax and H-4a ($J = ca$ 12.0 Hz) and between H-4ax and H-3ax ($J = 13.5$ Hz) denoted their *trans*-diaxial relationship, which was consistent with the NOE contour correlations between H-4a and H-3ax and between H-4ax and H-12*exo*. The assignments of the H-6 and H-12 protons were supported by the NOE effect between H-12*endo* and H-6β, as well as between H-6α and H-4a; additionally, both H-6α and H-12*exo* protons were assigned at lower fields due to their *cis*-relation with the nitrogen lone pair [19].

The ^{13}C NMR spectra of **5** and **6** were assigned taking into account the HMQC and HMBC connectivities (Tables 1 and 4). At lower fields six (**6**) or seven (**5**) carbon singlets for the acetoxy carbonyl groups and the quaternary carbons of the aromatic ring were observed. The carbon singlet at δ 140.3 of **5** was

Table 2. ^{1}H NMR and ROESY data for compounds **3a** and **3b** (J given in Hz in parentheses)

H	3a		3b	
	^{1}H NMR	ROESY	^{1}H NMR	ROESY
1	6.23 *d* (10.5)	H-2, H-10, H-11	6.21 *d* (10.5)	H-2, H-10
2	6.19 *dd* (10.5, 2.0)	H-1, H-3	6.17 *dd* (10.5, 1.5)	H-1, H-3
3	4.02 *ddd* (9.0, 6.5, 2.0)	H-4a, H-4β, *H*-2	3.96 *ddd* (10.5, 6.0, 1.5)	H-4a, H-4β, H-2
4α	2.11 *ddd* (13.0, 12.5, 9.1)	H-4β, H-12*exo*	2.26 *ddd* (13.5, 12.5, 10.0)	H-4β, H-12*exo*
4β	2.08 *ddd* (12.5, 6.5, 5.0)	H-4α, H-3, H-4a	2.16 *ddd* (12.5, 6.0, 5.0)	H-4α, H-3, H-4a
4a	3.73 *ddd* (13.0, 5.0, 1.0)	H-3, H-4β	3.41 *ddd* (13.0, 5.0,1.0)	H-3, H-4β, H-6
6	5.01 *s*	H-12*endo*, H-7	5.59 *s*	H-4a, H-7
7	6.80 *s*	H-6	6.96 *s*	H-6
10	6.74 *s*	H-1, H-11	6.72 *s*	H-1
11	3.90 *ddd* (6.5, 3.0, 1.0)	H-1, H-10, H-12*endo*	3.87 *ddd* (7.0, 2.5, 1.0)	H-12*endo*
12*endo*	3.35 *dd* (14.0, 6.5)	H-6, H-12*exo*, H-11	4.19 *dd* (14.0, 7.0)	H-12*exo*, H-11
12*exo*	3.30 *dd* (14.0, 3.0)	H-4α, H-12*endo*	3.01 *dd* (14.0, 2.5)	H-4α, H-12*endo*
-OCH_2O-	5.89 *d*–5,91 *d* (1.5)		5.88 *d*–5.90 *d* (1.5)	
3-OMe	3.37 *s*		3.38 *s*	

Table 3. ^{1}H NMR data for compounds **5**–**7** (*J* given in Hz in parentheses)

H	**5**	**6**	**7**
1	5.30 *d* (4.0)	5.32 *d* (4.5)	4.08 *d* (4.5)
2	5.55 *ddd* (4.0, 3.5, 2.0)	5.56 *ddd* (4.5, 3.5, 2.5)	4.17 *ddd* (4.5, 3.5, 2.5)
3eq	1.92 *dddd* (14.0, 3.5, 3.0, 2.5)	1.93 *dddd* (14.0, 3.5, 3.0, 3.0)	2.06 *dddd* (14.0, 3.5, 3.5, 3.0)
3ax	1.57 *dddd* (14.0, 13.5, 3.5, 2.0)	1.56 *dddd* (14.0, 13.5, 3.5, 2.5)	1.56 *dddd* (14.0, 12.5, 3.5, 2.5)
4eq	1.60 *dddd* (14.0, 5.5, 3.5, 3.0)	1.60 *dddd* (14.0, 5.5, 3.5, 3.0)	1.59 *dddd* (14.0, 5.0, 3.5, 3.0)
4ax	1.67 *dddd* (14.0, 13.5, 11.5, 2.5)	1.68 *dddd* (14.0, 13.5, 12.0, 3.0)	1.79 *dddd* (14.0, 12.5, 11.5, 3.5)
4a	3.01 *dd* (11.5, 5.5)	3.06 *dd* (12.0, 5.5)	2.95 *dd* (11.5, 5.0)
6α	4.16*d d* (17.5)	4.33 *d* (17.0)	4.22 *d* (17.5)
6β	3.74 *d* (17.5)	3.74 *d* (17.0)	3.80 *d* (17.5)
7		6.42 *s*	
10	6.16 *s*	6.43 *s*	7.24 *s*
11*endo*	2.01 *ddd*(12.5, 9.0, 4.5)	2.03 *ddd* (12.5, 9.0, 4.5)	2.01 *ddd* (12.0, 8.5, 4.5)
11*exo*	2.73 *ddd* (12.5, 10.5, 5.5)	2.75 *ddd* (12.5, 10.5, 5.5)	2.78 *ddd* (12.0, 9.5, 6.0)
12*endo*	2.80 *ddd* (12.5, 9.0, 5.5)	2.82 *dd* (12.5, 9.0, 5.5)	2.80 *ddd* (12.5, 8.5, 6.0)
12*exo*	3.40 *ddd* (12.5, 10.5, 4.5)	3.41 *ddd* (12.5, 10.5, 4.5)	3.42 *ddd* (12.5, 9.5, 4.5)
-OCH_2O-	5.80 *d*–5.82 *d* (1.5)	5.84 *d*–5.85 *d* (1.5)	5.88 *d*–5.90 *d* (1.5)
1-OAc	2.08 *s*	2.09 *s*	
2-OAc	2.08 *s*	2.09 *s*	
7-OMe	3.95 *s*		4.00 *s*

assigned to C-7 because of its three-bond correlation with the methoxyl group and both H-6 protons. Moreover, the additional methoxyl group strongly influenced the signals of C-6a and C-8. In contrast, the C-7 doublet of **6** was observed in the characteristic shift range (δ 106.4). The rest of the signals were very close for both **5** and **6**. Thus, the carbon singlets of the acetoxy carbonyl groups (*ca* δ 170) were assigned taking into account the three-bond connectivities with the H-1 or H-2 protons. The quaternary carbons of the aromatic ring, as well as C-10b, were easily assigned by means of long-range correlations.

The other new alkaloid (**7**) was isolated as a crystalline white compound. The EI mass spectrum showed a $[M]^+$ at *m/z* 319, which analysed for $C_{17}H_{21}NO_5$ and exhibited only a few prominent peaks, one being that at *m/z* 232, being consistent with a 1,2-disubstituted crinane alkaloid [10, 18]. The IR spectrum showed an intense absorption band at 3500–3300 cm^{-1}, characteristic of a hydroxyl group but no carbonyl absorption was observed. Its ^{1}H NMR spectrum (Table 3), recorded in $CDCl_3$, was similar to that of **5**; only the absence of the singlets attributable to the acetoxy groups was noteworthy. A ROESY experiment was used principally to afford information about the relative spatial distances of protons, allowing us to establish the axial orientation of H-1 by spatial proximity to H-10, H-3ax and H-4a. The small coupling constants of H-2 confirmed its equatorial disposition. All of these data would allow the assignment of the proposed structure, which has the same stereochemistry as the related alkaloid **5**. The ^{13}C assignments (Table 1) were confirmed considering the connectivities obtained from HMCQ and HMBC spectra.

Table 4. ROESY and HMBC data for compound **5**

H	ROESY	HMBC
1	H-2, H-3ax, H-10	C-11, C-4a, C-10a, CO
2	H-1, H-3eq, H-3ax	C-10b
3eq	H-3ax, H-2, H-4eq, H-4ax	
3ax	H-3eq, H-4a, H-4eq, H-2, H-1	
4eq	H-3eq, H-3ax, H4ax, H-4a	
4ax	H-3eq, H-4eq, H-12*exo*	C-2
4a	H-3ax, H-4eq, H-6α	C-12, C- 10a, C-11
6α	H-4a, H-6β	C-10a, C-12, C-7
6β	H-6α, H-12*endo*	C-10a, C-12, C-7, C-4a
10	H-1	C-8, C-6a, C-10b
11*endo*	H-11*exo*, H-12*endo*	C-10a
11*exo*	H-11*endo*, H-12*exo*	C-10a
12*endo*	H-12*exo*, H-11*endo*, H-6β	C-10b
12*exo*	*H*-12*endo*, H-11*exo*, H-4β	
-OCH_2O-		C-8, C-9
1-OAc		
2-OAc		
7-OMe		C-7

EXPERIMENTAL

General. Mps are uncorr. IR spectra were measured in KBr discs or as dry films. EIMS at 70 eV. ^{1}H, ^{13}C NMR, DEPT, ^{1}H COSY, HMQC, HMBC and ROESY spectra were recorded in a Varian VXR 500, using the solvent specified and TMS as int. standard. Chemical shifts are reported in δ units (ppm) and coupling constants (J) in Hz. Silica gel Merck (70–230 mesh) and silica gel SDS chromagel 60 A CC (230–400 mesh) were used for CC and flash CC, respectively. Sephadex LH-20 was used for gel filtration, and silica gel 60 F_{254} (Merck) for analyt. (0.25 mm) and prep. (1 mm) TLC. Spots on chromatograms were detected under UV (254 nm) and by Dragendorff's reagent.

Plant material. Bulbs of *B. orientalis* (L.) Ait ex Eckl were collected in February 1994 in the southern cape town of Knysna, South Africa. A voucher specimen (Viviers s.n.) has been deposited in the Bolus Herbarium, University of Cape Town, South Africa.

Extraction and isolation of alkaloids. Bulbs (5.1 kg) were crushed and macerated with EtOH for 48 hr. The extract was evapd under red. pres., the residue dissolved in H_2O and acidified to pH 4. After removing neutral material with Et_2O, the acidic soln was extracted with $CHCl_3$ to provide extract A. Basifying the soln to pH 8–9 and extracting it with $CHCl_3$ gave extract C. Finally, $CHCl_3$–MeOH (3:2) extraction of the basic soln gave extract D. Extracts A, C and D were combined (22.06 g) and subjected to CC on silica gel, eluting with CH_2Cl_2–MeOH (19:1), increasing the gradient for the last steps to (4:1). Five frs were afforded. Fr. I was subjected to flash CC using a Me_2CO–MeOH step gradient; after final purification on Sephadex LH-20, **2** (620 mg) and **5** (460 mg) were isolated. Fr. II was subjected to CC using a $CHCl_3$–MeOH step gradient, followed by further prep. TLC, eluting twice with MeOH and Me_2CO; after purification on Sephadex LH-20, **5** (62 mg), epibuphanisine (46 mg), buphanidrine (52 mg), **2** (18 mg), **6** (15 mg) and buphanisine (37 mg) were isolated. Compound **4** crystallized directly from fr. III; recrystallization with MeOH afforded 2.12 g. The rest of fr. III was purified in a similar manner to that described for fr. II, and **4** (205 mg), buphanisine (124 mg) and **1** (21 mg) were isolated. Finally, after purification by similar chromatographic processing to that described for fr. II, fr. IV afforded lycorine (87 mg), **7** (29 mg) and **3** (22 mg), and, fr. V, crinine (23 mg).

Crinamidine (**1**). Found: C, 65.05; H, 6.06; N, 4.35. Calc. for $C_{17}H_{19}NO_5$: C, 64.35; H, 5.99; N, 4.42%. Mp 215–217°. $[\alpha]_D^{22}$ – 10° ($CHCl_3$; *c* 0.1). CD $[\Theta]_{253}$ + 1625, $[\Theta]_{290}$ – 175. IR υ_{max} cm^{-1}: 3400–3200 (-OH), 1498, 1260, (epox.), 1043, 940 (-OCH_2O-), 805 (epox.). EIMS 70 eV, *m/z* (rel. int.): 317 $[M]^+$ (37), 288 (100), 258 (18), 245 (31), 244 (25), 217 (32), 205 (31), 204 (21), 203 (32), 189 (19), 173 (38), 115 (17), 85 (19), 57 (21), 56 (31). ^{1}H NMR (500 MHz, $CDCl_3$): δ 1.56 (1H, *ddd*, J = 13.5, 12.5, 3.0 Hz, H-4β), 1.61 (1H, *dddd*, J = 13.5, 5.5, 2.0, 1.5 Hz, H-4α), 2.0 (1H, *ddd*, J = 12.5, 9.0, 5.0 Hz, H-11*endo*), 2.37 (1H, *ddd*, J = 12.5, 10.5, 5.5 Hz, H-11*exo*), 2.77 (1H, *ddd*, J = 12.5, 9.0, 5.5 Hz, H-12*endo*), 3.17 (1H, *ddd*, J = 12.5, 10.5, 5.0 Hz, H-12*exo*), 3.17 (1H, *dd*, J = 12.5, 5.5 Hz, H-4a), 3.26 (1H, *ddd*, J = 4.0, 2.5, 1.5 Hz, H-2), 3.71 (1H, *d*, J = 17.5 Hz, H-6β), 3.75 (1H, *d*, J = 4.0 Hz, H-1), 3.95 (3H, *s*, 7-OMe), 4.19 (1H, *d*, J = 17.5 Hz, H-6α), 4.48 (1*H*, *ddd*, J = 3.0, 2.5, 2.0 Hz, H-3), 5.85–5.86 (2H, 2*d*, J = 1.5 Hz, OCH_2O), 6.61 (1H, *s*, H-10). ^{13}C NMR (50 MHz, $CDCl_3$): Table 1.

6-*Hydroxycrinamine* (**3a** *and* **3b**). Found: C, 63.41; H, 6.07; N, 4.33. Calc. for $C_{17}H_{19}NO_5$: C, 64.35; H, 5.99; N, 4.42%. Mp 150–152°. $[\alpha]_D^{22}$ + 40° ($CHCl_3$; *c* 0.5). CD $[\Theta]_{256}$ – 1565, $[\Theta]_{266}$ + 4087. IR υ_{max} cm^{-1}: 3420 (-OH), 2926, 1481, 1248, 1038, 933 (-OCH_2O-). EIMS 70 eV, *m/z* (rel. int.): 317 $[M]^+$ (1), 285 $[M - MeOH]^+$ (39), 284 (10), 269 (20), 268 $[M - MeOH - OH]^+$ (100), 258 (10), 227 (25), 209 (26). ^{1}H NMR (500 MHz, $CDCl_3$): Table 2; ^{13}C NMR (50 MHz, $CDCl_3$): Table 1.

1-*Epibowdensine* (**5**). Found: C, 61.55; H, 6.12; N, 3.51. $C_{21}H_{25}NO_7$ requires: C, 62.53; H, 6.20; N, 3.47%. Mp 124-126°. $[\alpha]_D^{22}$ + 4° ($CHCl_3$; *c* 1.1). CD $[\Theta]_{256}$ + 2130, $[\Theta]_{286}$-132. IR υ_{max} cm^{-1}: 2946, 1740 (>C=O), 1617, 1478, 1367, 1245, 1041, 942 (-OCH_2O-), 751. EIMS 70 eV, *m/z* (rel. int.): 403 $[M]^+$ (100), 344 $[M - OAc]^+$ (81), 314 $[M - OAc - OMe]^+$ (23), 284 $[M - OAc - HOAc]^+$ (63), 283 (22), 272 (31), 256 (21), 255 (27), 254 (37), 232 (36), 231 (28), 202 (26). ^{1}H NMR (500 MHz, $CDCl_3$): Table 3; ^{13}C NMR (50 MHz, $CDCl_3$): Table 1.

1-*Epidemethoxybowdensine* (**6**). Found: C, 63.61; H, 6.08; N, 3.81. $C_{20}H_{23}NO_6$ requires: C, 64.34; H, 6.17; N, 3.75%. Mp 96–98°. $[\alpha]_D^{22}$ + 20° ($CHCl_3$; *c* 0.78). CD $[\Theta]_{256}$ + 3850, $[\Theta]_{289}$ – 225. IR υ_{max} cm^{-1}: 2922, 1734 (>C=O), 1478, 1367, 1233, 1036, 942 (-OCH_2O-), 751. EIMS 70 eV, *m/z* (rel. int.): 373 $[M]^+$ (100), 315 (24), 314 $[M - OAc]^+$ (75), 254 $[M - OAc - HOAc]^+$ (60), 253, (23), 242 (25), 226 (22), 225 (24), 224 (27), 202 (41), 201 (37). ^{1}H NMR (500 MHz, $CDCl_3$): Table 3; ^{13}C NMR (50 MHz, $CDCl_3$): Table 1.

1-*Epideacetylbowdensine* (**7**). Found: C, 62.78; H, 6.65; N, 4.45. $C_{17}H_{21}NO_5$ requires: C, 63.95; H, 6.58; N, 4.39%. Mp 162–164°. $[\alpha]_D^{22}$ + 22° ($CHCl_3$; *c* 0.47). CD $[\Theta]_{256}$ + 4520, $[\Theta]_{283}$ – 75. IR υ_{max} cm^{-1}: 3450–3200 (-OH), 2924, 1618, 1473, 1373, 1274, 1215, 1045, 939, (-OCH_2O-), 755. EIMS 70 eV, *m/z* (rel. int.): 319 $[M]^+$ (100), 302 (12), 275 (29), 246 (20), 232 (76), 220 (25), 219 (22), 203 (18), 57 (38), 56 (25). ^{1}H NMR (500 MHz, $CDCl_3$): Table 3; ^{13}C NMR (50 MHz, $CDCl_3$): Table 1.

Crinine [6], *buphanisine* [6], *buphanidrine* [6], *undulatine* [6], *epibuphanisine* [17], *crinamine* [5, 10, 20] and *lycorine* [4, 21]. These were identified by comparison of their chromatographic and spectroscopic properties (TLC, IR, CD, MS, ^{1}H and ^{13}C NMR) with those of authentic samples obtained from other plant sources.

Acknowledgements—Part of this work was supported financially by CICYT and the Comissionat per a

Universitats i Recerca, Generalitat de Catalunya. W.E.C. and S.M. thank the University of Cape Town for financial support. Thanks are also due to M. Viviers for the collection and authentication of plant material. G.R.A. thanks the Instituto de Cooperación Ibero-americana for the provision of a research fellowship.

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