Structure of New Alkaloids, Evonine and Neoevonine: *X*-Ray Analysis of Bromoacetylneoevonine Monohydrate

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The structures, and absolute configurations, of two Celastraceae alkaloids, evonine and neoevonine, isolated from *Euonymus Sieboldiana* Blume, have been established unambiguously by *X*-ray analysis of bromoacetylneoevonine. These alkaloids are characterized by the presence of a macrocyclic evoninic acid diester substituted on a highly oxygenated sesquiterpene nucleus. The crystals are monoclinic, space group $P2_1$, with $Z = 2$ in a unit cell of dimensions: $a = 14{\cdot}841(4)$, $b = 14{\cdot}645(4)$, $c = 9{\cdot}642(3)$ Å, $\beta = 90{\cdot}0(2)°$. The structure was elucidated from diffractometer data by the heavy-atom method and the atomic co-ordinates were refined by Fourier and least-squares calculations to R 0·091 for 1973 independent reflections. The absolute configuration was determined by the anomalous dispersion method and by comparison with the known absolute stereochemistry of the evoninic acid moiety.

THE Celastraceae alkaloids, evonine ($C_{36}H_{43}NO_{17}$, m.p. 184—190 °C) [1] and neoevonine ($C_{34}H_{41}NO_{16}$, m.p. 264—265 °C) [2] were isolated from the fruits of *Euonymus Sieboldiana* Blume. Evonine has been characterized as a polyhydroxylated sesquiterpene having five acetates and an evoninic acid residue.[1] Another alkaloid, neoevonine was shown to be deacetylevonine, based on the fact that acetylation of neoevonine afforded evonine.[2] To establish the structure of these compounds an *X*-ray crystal analysis of bromoacetylneoevonine monohydrate was taken, and our results now show that this derivative has the structure (I). The structure of evonine (II) and of neoevonine (III) have been established by a combination of the chemical evidence and the results from this crystal-structure determination.

EXPERIMENTAL

Bromoacetylneoevonine (m.p. 138·5 °C) was prepared by bromoacetylation of neoevonine ($BrCH_2{\cdot}COBr$–NaH–tetrahydrofuran, room temperature) and crystallized from ethanol as colourless needles elongated along the *c*-axis.

Crystal Data.—$C_{36}H_{42}NO_{17}Br,H_2O$, $M = 858{\cdot}6$. Monoclinic, $a = 14{\cdot}841(4)$, $b = 14{\cdot}645(4)$, $c = 9{\cdot}642(3)$ Å, $\beta = 90{\cdot}0(2)°$, $U = 2095{\cdot}7$ Å^3, $D_m = 1{\cdot}37$ (by flotation), $Z = 2$, $D_c = 1{\cdot}36$. $F(000) = 892$. Space group $P2_1$ (C_2^2, No. 4)

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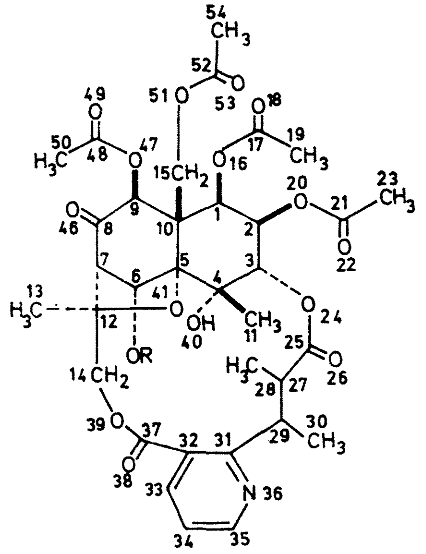
[1] M. Pailer and R. Libiseller, *Monatsh.*, 1962, **93**, 511.

[2] K. Sugiura, Y. Shizuri, H. Wada, K. Yamada, and Y. Hirata, *Tetrahedron Letters*, 1971, 2733.

from systematic absences: $0k0$ for k odd. Cu-K_α radiation, $\lambda = 1{\cdot}5418$ Å; μ(Cu-K_α) $= 16{\cdot}09$ cm^{-1}.



	R
(I)	CO·CH$_2$Br
(II)	CO·CH$_3$
(III)	H

Crystallographic Measurements.—Lattice constants and intensities were measured at 5 °C, by use of a Hilger and Watts automatic four-circle diffractometer Y-290 with Cu-K_α radiation. The space group was determined from the systematic absences. Integrated intensities were measured for $\theta \lesssim 65°$ by the θ—2θ scan technique using Cu-K_α radiation. A total of 2592 independent reflections were collected above background, of which 1973 had intensities $>3\sigma(F)$.[3]

Structure Analysis.—The initial co-ordinates of the bromine atom were obtained from the Harker section at $x = 0{\cdot}09$, $z = -0{\cdot}58$, the y co-ordinate being arbitrarily assigned at 0·25. Structure factors phased on the bromine atom alone were calculated (R 0·463), and from these the first three-dimensional electron density map was computed. The positions of 16 atoms were then assigned, and the remaining atom positions except the oxygen atom of the solvated water, were derived successively from 4 cycles of subsequent block-diagonal least-squares refinements and Fourier syntheses; R was reduced to 0·16. The position of the oxygen of the solvent water was assigned from the difference Fourier synthesis calculated at this stage. Further refinement was made by 4 cycles of block-diagonal least-squares calculations with anisotropic temperature factors for bromine; the final R was 0·091. The final structure factors are listed in Supplementary Publication No. SUP 20387 (4 pp., 1 microfiche).* After the final cycle of refinement, the shift of atomic co-ordinates were $<0{\cdot}25\sigma$. Figure 1 is a perspective drawing of a crystal chemical unit along the c axis. The hydrogen atom contributions have not been included in the structure-factor calculations. The final fractional co-ordinates and temperature factors with standard deviations are given in Table 1. The atomic scattering factors used were taken from ref. 4.

All computations were performed on a FACOM 230 = 60 at the Data Processing Centre, Kyoto University: data reduction and Patterson synthesis, DRPS by K. Sasaki; structure factors, diagonal least-squares, and Fourier with isotropic temperature factors, DLSF by C. Katayama and K. Sasaki; structure factors, block-diagonal least-squares, and Fourier synthesis with anisotropic temperature factors, ATLS by C. Katayama and K. Sasaki.

Absolute Configuration.—In the final stage of the analysis the absolute configuration of the molecule was determined by Bijvoet's anomalous dispersion method,[5] based on the bromine atom. The differences between $I(hkl)$ and $I(\bar{h}\bar{k}\bar{l})$ were measured on a Hilger and Watts four-circle diffractometer, by use of Cu-K_α radiation. Structure factors were calculated for all the hkl and $\bar{h}\bar{k}\bar{l}$ reflections, with a scattering factor for the bromine of the form: $f_{\mathrm{Br}} = f_{\mathrm{Br}} + \Delta f'_{\mathrm{Br}} + i\Delta f''_{\mathrm{Br}}$, where $\Delta f'_{\mathrm{Br}} = -0{\cdot}9$ and $\Delta f''_{\mathrm{Br}} = 1{\cdot}5$. The results (Table 2) indicate that the absolute configuration had been established and that the co-ordinates in Table 1 give the correct absolute configuration if a left-handed co-ordinate system is adopted. Furthermore, the absolute stereochemistry of evoninic acid [(2S,3S)-3-(3-carboxy-2-pyridyl)-2-methylbutyric acid] (IV), which

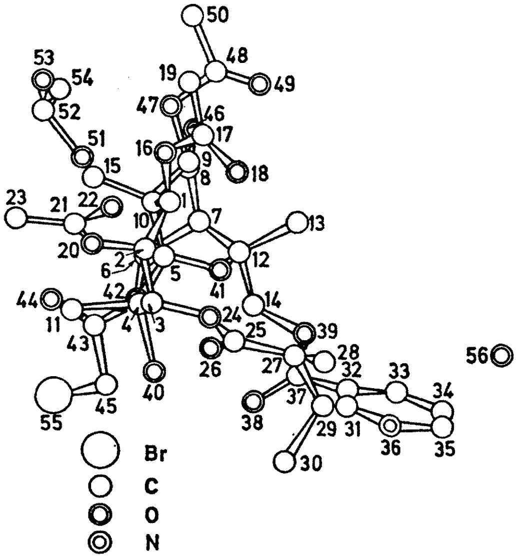
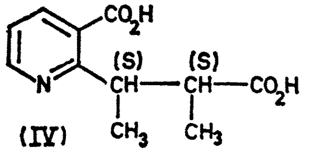


FIGURE 1



(IV)

was derived from evonine, had been assigned by means of chemical correlation reactions.[1] Both results show that the absolute configuration of bromoacetylneoevonine can be represented by (I). Both Figures 1 and 2 have been drawn with reversal of the x co-ordinate, so that they portray correctly the absolute configuration.

RESULTS AND DISCUSSION

The present analysis has established the molecular structure and absolute configuration of bromoacetylneoevonine, and thus of evonine and neoevonine as (II)

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* See note about Supplementary Publications in Notice to Authors No. 7, in *J. Chem. Soc.* (*A*), 1970, Issue No. 20 (items less than 4 pp. are supplied as full size copies).

[3] K. Sasaki and Y. Hirata, *J. Chem. Soc.* (*B*), 1971, 1565.

[4] 'International Tables for X-Ray Crystallography,' vol. 3, Kynoch Press, Birmingham, 1962.

[5] J. M. Bijvoet, A. F. Peerdeman, and A. J. van Bommel, *Nature*, 1951, **168**, 271.

and (III). The sesquiterpene carbon skeleton, belonging to the eudalene type, carries four acetyl groups (^{1}H n.m.r.: δ 1·90, 2·05, 2·11, and 2·16 p.p.m., each 3H) and an evoninic acid residue. The sesquiterpene nucleus is a 6-oxabicyclo[3,2,1]octane ring fused with a chair cyclohexane ring, which forms a thirteen-membered ring with an evoninic acid residue. Broadly speaking, the molecular shape shows that the acetyl groups are on the β-side of the *trans*-fused cyclohexane rings, whereas the

TABLE 1

Atomic co-ordinates (as fractions of the cell edges), with their estimated standard deviations in parentheses, and temperature factors

	x	y	z	B/Å^2
C(1)	0·4056(10)	0·4449(11)	0·1197(16)	3·15
C(2)	0·3301(10)	0·4037(11)	0·2109(16)	3·24
C(3)	0·2386(10)	0·4134(11)	0·1384(16)	3·18
C(4)	0·2366(10)	0·3851(11)	−0·0116(17)	3·29
C(5)	0·3190(9)	0·4265(11)	−0·0974(15)	2·46
C(6)	0·3243(9)	0·3950(11)	−0·2552(15)	2·72
C(7)	0·3756(10)	0·4805(12)	−0·3156(16)	3·39
C(8)	0·4719(10)	0·4735(12)	−0·2614(16)	3·22
C(9)	0·4811(9)	0·4701(11)	−0·1035(14)	2·27
C(10)	0·4121(9)	0·4111(10)	−0·0272(15)	2·30
C(11)	0·2327(11)	0·2806(12)	−0·0214(17)	4·00
C(12)	0·3257(10)	0·5608(11)	−0·2423(16)	3·06
C(13)	0·3819(11)	0·6474(13)	−0·2299(18)	4·12
C(14)	0·2375(12)	0·5846(13)	−0·3172(19)	4·62
C(15)	0·4463(10)	0·3084(11)	−0·0299(17)	3·35
O(16)	0·4913(7)	0·4326(8)	0·1847(11)	3·79
C(17)	0·5200(13)	0·4913(15)	0·2875(21)	5·56
O(18)	0·4623(9)	0·5513(10)	0·3270(14)	6·37
C(19)	0·6083(13)	0·4677(16)	0·3423(21)	5·92
O(20)	0·3437(6)	0·3093(7)	0·2343(10)	2·75
C(21)	0·3743(11)	0·2838(12)	0·3629(17)	3·62
O(22)	0·3968(9)	0·3384(10)	0·4477(15)	5·78
C(23)	0·3788(13)	0·1824(15)	0·3730(22)	5·70
O(24)	0·2206(7)	0·5131(7)	0·1419(11)	3·20
C(25)	0·1819(11)	0·5514(13)	0·2528(19)	4·65
O(26)	0·1667(9)	0·5087(10)	0·3550(14)	5·91
C(27)	0·1591(11)	0·6508(12)	0·2202(17)	3·76
C(28)	0·1504(13)	0·7019(14)	0·3576(20)	4·95
C(29)	0·0748(11)	0·6492(12)	0·1295(17)	3·69
C(30)	−0·0207(12)	0·6370(14)	0·2058(20)	4·92
C(31)	0·0721(11)	0·7366(13)	0·0418(17)	4·07
C(32)	0·0983(11)	0·7379(13)	−0·0972(17)	3·94
C(33)	0·0983(13)	0·8194(14)	−0·1692(19)	4·96
C(34)	0·0689(13)	0·8968(15)	−0·1002(21)	5·62
C(35)	0·0479(11)	0·8924(13)	0·0395(19)	4·75
N(36)	0·0455(9)	0·8145(10)	0·1047(14)	4·19
C(37)	0·1261(11)	0·6544(12)	−0·1792(18)	3·88
O(38)	0·0814(8)	0·5847(9)	−0·1716(12)	4·73
O(39)	0·1969(8)	0·6649(8)	−0·2514(12)	4·44
O(40)	0·1536(7)	0·4188(8)	−0·0725(12)	4·05
O(41)	0·3032(6)	0·5214(7)	−0·1053(10)	2·76
O(42)	0·2381(7)	0·3918(8)	−0·3223(11)	3·71
C(43)	0·2043(11)	0·3138(13)	−0·3733(18)	4·34
O(44)	0·2447(7)	0·2441(9)	−0·3687(12)	4·95
C(45)	0·1139(13)	0·3393(15)	−0·4403(22)	5·99
O(46)	0·5313(7)	0·4804(8)	−0·3395(11)	3·73
O(47)	0·5705(6)	0·4428(7)	−0·0772(10)	3·01
C(48)	0·6299(12)	0·5081(13)	−0·0519(19)	4·63
O(49)	0·6119(9)	0·5853(11)	−0·0445(15)	6·73
C(50)	0·7234(15)	0·4689(18)	−0·0305(25)	7·42
O(51)	0·4802(7)	0·2931(7)	−0·1712(11)	3·19
C(52)	0·5603(11)	0·2523(15)	−0·1871(18)	4·72
O(53)	0·6070(8)	0·2243(10)	−0·0955(13)	5·89
C(54)	0·5927(11)	0·2521(14)	−0·3386(17)	4·48
Br(55)	0·0865(2)	0·2520(3)	−0·5817(3)	*
O(56)	0·1647(15)	0·9947(19)	0·4736(27)	15·10

* For the bromine atom anisotropic temperature factors were of the form:

$$T = \exp[-(\beta_{11}h^2 + \beta_{22}k^2 + \beta_{33}l^2 + \beta_{12}hk + \beta_{13}hl + \beta_{23}kl)]$$

with parameters.

β_{11}	β_{22}	β_{33}	β_{12}	β_{13}	β_{23}
0·01214	0·01590	0·02037	−0·00967	−0·01010	−0·00280

TABLE 2

Comparison of the observed and calculated intensity differences used for the establishment of absolute configuration

h	k	l	$\|F_c(hkl)\|$	$\|F_c(\bar{h}\bar{k}l)\|$	$I_o(hkl)$ $I_o(\bar{h}\bar{k}l)$
$\bar{6}$	1	1	34·29	36·32	>
$\bar{5}$	4	1	26·66	29·37	>
$\bar{3}$	1	1	135·77	136·13	>
$\bar{2}$	7	1	55·31	55·26	<
$\bar{1}$	5	1	62·18	61·02	<
$\bar{9}$	1	2	37·42	37·21	<
$\bar{7}$	2	2	30·04	29·63	<
$\bar{6}$	1	2	16·28	17·22	>
$\bar{5}$	4	2	28·75	27·74	<
$\bar{3}$	1	2	60·66	60·52	<
$\bar{2}$	7	2	31·18	29·23	<
$\bar{1}$	5	2	23·42	23·59	>
$\bar{6}$	1	3	45·60	44·01	<
$\bar{5}$	3	3	66·57	65·21	<
$\bar{2}$	2	3	14·68	18·25	>
$\bar{5}$	4	4	17·16	17·48	>
$\bar{3}$	1	4	37·06	38·36	>
$\bar{3}$	1	5	30·96	29·98	<
$\bar{3}$	1	6	40·80	40·87	>
2	2	1	69·75	71·45	>
4	2	1	40·65	40·92	>
1	3	2	15·06	17·06	>
3	2	2	46·92	49·11	>
4	2	2	26·45	27·21	>
1	3	3	35·56	37·04	>
2	2	3	91·49	91·03	<
3	2	3	40·67	42·25	>
4	2	3	36·55	37·42	>
1	3	4	55·82	57·34	>
2	2	4	18·70	21·03	>
3	2	4	41·74	39·05	<
1	3	5	40·70	40·32	<

TABLE 3

Molecular geometry

(*a*) Bond distances (Å)

C(1)–C(2)	1·55	O(20)–C(21)	1·37
C(1)–C(10)	1·50	C(21)–O(22)	1·19
C(1)–O(16)	1·42	C(21)–C(23)	1·48
C(2)–C(3)	1·54	O(24)–C(25)	1·34
C(2)–O(20)	1·41	C(25)–O(26)	1·19
C(3)–C(4)	1·51	C(25)–C(27)	1·53
C(3)–O(24)	1·48	C(27)–C(28)	1·53
C(4)–C(5)	1·60	C(27)–C(29)	1·53
C(4)–C(11)	1·53	C(29)–C(30)	1·61
C(4)–O(40)	1·45	C(29)–C(31)	1·54
C(5)–C(6)	1·59	C(31)–C(32)	1·39
C(5)–C(10)	1·56	C(31)–N(36)	1·35
C(5)–O(41)	1·44	C(32)–C(33)	1·38
C(6)–C(7)	1·58	C(32)–C(37)	1·52
C(6)–O(42)	1·43	C(33)–C(34)	1·39
C(7)–C(8)	1·53	C(34)–C(35)	1·38
C(7)–C(12)	1·56	C(35)–N(36)	1·30
C(8)–C(9)	1·53	C(37)–O(38)	1·22
C(8)–O(46)	1·16	C(37)–O(39)	1·27
C(9)–C(10)	1·53	O(42)–C(43)	1·34
C(9)–O(47)	1·41	C(43)–O(44)	1·19
C(10)–C(15)	1·58	C(43)–C(45)	1·53
C(12)–C(13)	1·52	C(45)–Br(55)	1·91
C(12)–C(14)	1·53	O(47)–C(48)	1·33
C(12)–O(41)	1·46	C(48)–O(49)	1·16
C(14)–O(39)	1·47	C(48)–C(50)	1·51
C(15)–O(51)	1·47	O(51)–C(52)	1·33
O(16)–C(17)	1·38	C(52)–O(53)	1·20
C(17)–O(18)	1·29	C(52)–C(54)	1·54
C(17)–C(19)	1·45		

TABLE 3 (*Continued*)

(*b*) Angles (deg.)

C(2)–C(1)–C(10)	117	C(1)–O(16)–C(17)	121
C(2)–C(1)–O(16)	110	O(16)–C(17)–O(18)	115
C(10)–C(1)–O(16)	108	O(16)–C(17)–C(19)	113
C(1)–C(2)–C(3)	110	O(18)–C(17)–C(19)	131
C(1)–C(2)–O(20)	112	C(2)–O(20)–C(21)	117
C(3)–C(2)–O(20)	107	O(20)–C(21)–O(22)	122
C(2)–C(3)–C(4)	115	O(20)–C(21)–C(23)	110
C(2)–C(3)–O(24)	104	O(22)–C(21)–C(23)	128
C(4)–C(3)–O(24)	107	C(3)–O(24)–C(25)	120
C(3)–C(4)–C(5)	112	O(24)–C(25)–O(26)	122
C(3)–C(4)–C(11)	110	O(24)–C(25)–C(27)	109
C(3)–C(4)–O(40)	108	O(26)–C(25)–C(27)	129
C(5)–C(4)–C(11)	112	C(25)–C(27)–C(28)	108
C(5)–C(4)–O(40)	108	C(25)–C(27)–C(29)	107
C(11)–C(4)–O(40)	106	C(28)–C(27)–C(29)	116
C(4)–C(5)–C(6)	115	C(27)–C(29)–C(30)	117
C(4)–C(5)–C(10)	113	C(27)–C(29)–C(31)	109
C(4)–C(5)–O(41)	106	C(30)–C(29)–C(31)	109
C(6)–C(5)–C(10)	109	C(29)–C(31)–C(32)	122
C(6)–C(5)–O(41)	104	C(29)–C(31)–N(36)	118
C(10)–C(5)–O(41)	108	C(32)–C(31)–N(36)	120
C(5)–C(6)–C(7)	98	C(31)–C(32)–C(33)	120
C(5)–C(6)–O(42)	113	C(31)–C(32)–C(37)	125
C(7)–C(6)–O(42)	107	C(33)–C(32)–C(37)	115
C(6)–C(7)–C(8)	106	C(32)–C(33)–C(34)	117
C(6)–C(7)–C(12)	102	C(33)–C(34)–C(35)	120
C(8)–C(9)–C(12)	110	C(34)–C(35)–N(36)	121
C(7)–C(8)–C(9)	115	C(31)–N(36)–C(35)	121
C(7)–C(8)–O(46)	119	C(32)–C(37)–O(38)	120
C(9)–C(8)–O(46)	125	C(32)–C(37)–O(39)	114
C(8)–C(9)–C(10)	116	O(38)–C(37)–O(39)	126
C(8)–C(9)–O(47)	106	C(14)–O(39)–C(37)	119
C(10)–C(9)–O(47)	113	C(5)–O(41)–C(12)	112
C(1)–C(10)–C(5)	108	C(6)–O(42)–C(43)	122
C(1)–C(10)–C(9)	108	O(42)–C(43)–O(44)	122
C(1)–C(10)–C(15)	110	O(42)–C(43)–C(45)	106
C(5)–C(10)–C(9)	107	O(44)–C(43)–C(45)	132
C(5)–C(10)–C(15)	115	C(43)–C(45)–Br(55)	109
C(9)–C(10)–C(15)	108	C(9)–O(47)–C(48)	117
C(7)–C(12)–C(13)	114	O(47)–C(48)–O(49)	124
C(7)–C(12)–C(14)	111	O(47)–C(48)–C(50)	111
C(7)–C(12)–O(41)	104	O(49)–C(48)–C(50)	125
C(13)–C(12)–C(14)	108	C(15)–O(51)–C(52)	119
C(13)–C(12)–O(41)	111	O(51)–C(52)–O(53)	126
C(14)–C(12)–O(41)	108	O(51)–C(52)–C(54)	113
C(12)–C(14)–O(39)	109	O(53)–C(52)–C(54)	121
C(10)–C(15)–O(51)	106		

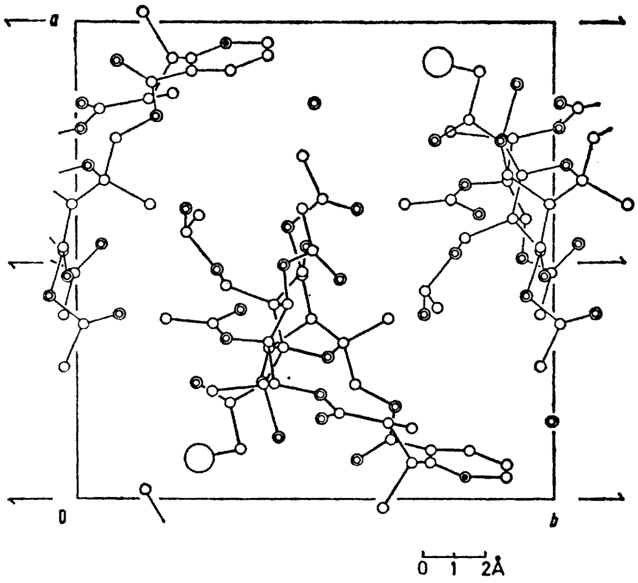

FIGURE 2

evoninic acid residue is on the α-side. The interatomic distances and valency angles are listed in Table 3. The mean estimated standard deviations of bond distances is *ca.* 0·03 Å and of valency angles is *ca.* 1·2°. For the most part the corresponding bond lengths and angles are not significantly different from expected values. The mean lengths of the various types of bond are calculated as: C–C 1·54, C–O 1·44, aromatic C–O 1·34, C=O 1·20, and C–C (pyridine ring) 1·38 Å. The C(37)–O(39) bond distance (1·27 Å) is smaller than the mean aromatic C–O single bond on account of the interaction with the neighbouring pyridine ring. The O(18)–C(17)–C(19) and O(44)–C(43)–C(45) bond angles (131 and 132°) are greater than the values for other acetyl groups owing to the steric repulsions. Some intramolecular distances are listed in Table 4.

Consideration of the deviations from the best plane through the various atom groups (Table 5) show that the six-membered ring C(1)—(5),(10) has a slightly distorted chair conformation. In the 6-oxabicyclo[3,2,1]octane ring the angle between the plane C(7)—(9),O(46) and the plane C(5),C(7),C(12),O(41) of the α-envelope five-membered ring is 75°, and the angle between the plane C(2),C(3),C(5),C(6) and that of the pyridine ring is 73°.

TABLE 4

Some intramolecular non-bonded contacts (Å)

C(2) · · · O(18)	3·12	C(17) · · · O(22)	3·28
C(2) · · · O(26)	3·19	C(37) · · · O(41)	3·32
C(11) · · · C(15)	3·20	O(40) · · · C(43)	3·37
C(11) · · · O(42)	3·33	O(46) · · · C(48)	3·16
O(16) · · · C(21)	3·28	O(46) · · · O(51)	3·28
O(16) · · · O(22)	3·21	O(47) · · · O(53)	3·25
O(16) · · · C(48)	3·27	O(44) · · · Br(55)	3·12

TABLE 5

Equations of least-squares planes in the form $lX + nY + nZ = p$ where X, Y, and Z are co-ordinates in Å. Deviations (Å) of atoms from the planes are listed in square brackets; atoms not included in the derivations of the planes are italicized

	l	*m*	*n*	*p*
Plane (1): Cyclohexane ring	0·0836	0·9906	0·1087	6·4645,
[C(2) 0·02, C(3) −0·02, C(5) 0·02, C(10) −0·02, *C(1)* 0·62 *C(4)* −0·60, *C(7)* 0·64, *C(8)* 0·72]				
Plane (2): 6-Oxabicyclo[3,2,1]-octane ring	0·0088	0·9977	0·0670	5·3079
[C(5) 0·04, C(7), −0·03, C(12) −0·05, O(41) 0·06, *C(6)* −0·70]				
Plane (3): 6-Oxabicyclo[3,2,1]-octane ring	0·8826	0·2357	0·4067	6·8537
[C(7) 0·01, C(8) −0·04, C(9) 0·01, O(46) 0·02, *C(5)* −0·64, *C(10)* −0·81]				
Plane (4): Pyridine ring	0·9461	0·1686	0·2763	2·9436
[C(31) 0·00, C(32) 0·00, C(33) 0·01, C(34) −0·03, C(35) 0·03, N(36) −0·02, *C(37)* −0·03 ,*C(29)* 0·06, *O(38)* −0·81, *C(49)* 0·79]				

TABLE 6

Intermolecular distances (Å)

Contact	Distance
(*a*) Carbon–carbon	
C(30) ··· $C(34^{I})$	3·73
C(50) ··· $C(34^{V})$	3·49
C(50) ··· $C(35^{V})$	3·59
(*b*) Oxygen–nitrogen	
O(40) ··· $N(36^{II})$	3·34
(*c*) Oxygen–oxygen	
O(42) ··· $O(22^{II})$	3·33
O(44) ··· $O(22^{II})$	3·18
O(46) ··· $O(18^{II})$	3·53
O(46) ··· $O(22^{II})$	3·54
(*d*) Carbon–bromine	
C(33) ··· $Br(55^{III})$	3·78
(*e*) Carbon–oxygen	
C(16) ··· $O(22^{II})$	3·17
C(7) ··· $O(22^{II})$	3·10
C(14) ··· $O(26^{II})$	3·52
C(15) ··· $O(49^{V})$	3·46
C(23) ··· $O(46^{V})$	3·27
C(23) ··· $O(49^{V})$	3·48
C(35) ··· $O(40^{IV})$	3·03
C(43) ··· $O(22^{II})$	3·36
O(44) ··· $C(23^{II})$	3·31
C(45) ··· $O(26^{II})$	3·27
O(46) ··· $C(19^{II})$	3·28
C(52) ··· $O(18^{V})$	3·26
O(53) ··· $C(13^{V})$	3·34
C(54) ··· $O(18^{V})$	3·05

Roman numerals as superscripts refer to the following equivalent positions relative to the reference molecule at *x*, *y*, *z*:

I $-x, -\frac{1}{2}+y, -z$
II $x, y, -1+z$
III $-x, \frac{1}{2}+y, -1-z$
IV $-x, \frac{1}{2}+y, -z$
V $1-x, -\frac{1}{2}+y, -z$

The arrangement of molecules in a crystal, as viewed along the *c*-axis, is shown in Figure 2. The intermolecular contacts were between the oxygen atom of the solvated water and a neighbouring molecule and are greater than the sum of the van der Waals radii. All intermolecular contacts were calculated, and the most significant contacts are given in Table 6. The packing is efficient with several contacts approaching the sum of the van der Waals radii; the shortest contact excluding hydrogen atoms is 3·03 Å for C(35) ··· $O(40)^{IV}$, which is between the hydroxy-group on a cyclohexane ring and the carbon atom in a neighbouring pyridine ring.

Recently, mytoline has been isolated from the same family and its structure was elucidated by *X*-ray crystallography.[6] The structure of the C_{15}-nucleus in mytoline is similar to the C_{15}-skeleta of our two alkaloids.

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[6] S. M. Kupchan, R. M. Smith, and R. F. Bryan, *J. Amer. Chem. Soc.*, 1970, **92**, 6667.