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ALKALOIDS OF FORMOSAN *FISSISTIGMA* AND *GONIOTHALAMUS* SPECIES

SHENG-TEH LU, YANG-CHANG WU and SHIOW-PIAW LEOU

School of Pharmacy, Kaohsiung Medical College, 100 Shih-Chuan 1st Road, San-Min District, Kaohsiung, Taiwan

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Key Word Index—*Fissistigma glaucescens*; *F. oldhamii*; *Goniothalamus amuyon*; Annonaceae; alkaloids; quaternary phenanthrene alkaloid; *N*-methylatherosperminium.

Abstract—Separation of the basic fractions from Formosan *Fissistigma glaucescens*, *F. oldhamii* and *Goniothalamus amuyon* afforded one new quaternary phenanthrene alkaloid, *N*-methylatherosperminium (**15**), along with the known alkaloids, (−)-discretamine (**1**), (−)-tetrahydropalmatine (**2**), palmatine (**3**), (−)-asimilobine (**4**), (−)-norannuradhapurine (**5**), (−)-crebanine (**6**), (−)-calycinine (fissoldine, fissistigine A) (**7a**), (−)-anolobine (**8**), (−)-xylopine (**9**), (−)-anonaine (**10a**), oxocrebanine (**11**), liriodenine (**12**), atherosperminine (**13**), *N*-noratherosperminine (**14**) and (+)-*O*-methylflavinantine (*O*-methylpallidine) (**16**).

INTRODUCTION

Fissistigma glaucescens and *F. oldhamii* are perennial climbing shrubs indigenous to the broad leaved tree zone of Taiwan [1, 2]. The roots and stems of the latter have been used in folk medicine for muscular atrophy, hepatomegaly and hepatosplenomegaly [3]. *Goniothalamus amuyon* is a small tree or shrub indigenous to southern Taiwan near the coastal regions [2]. Extracts of its seeds have been used for the treatment of oedema and rheumatism [3].

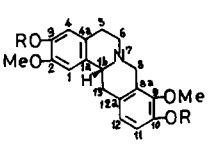
To our knowledge there is no report about the alkaloids of these plants growing in Taiwan. In order to understand the alkaloidal components of these three plants used medicinally, it was decided to undertake a phytochemical investigation. This paper reports the isolation and characterization of the alkaloidal components from these three species.

RESULTS AND DISCUSSION

Plant materials were collected in January (*F. glaucescens*) and December (*F. oldhamii* and *G. amuyon*), and the extraction and separation of the alkaloids were performed by usual procedures described in the Experimental. The following alkaloids were isolated: (a) tetrahydroprotoberberines: (−)-discretamine (**1**) and (−)-tetrahydropalmatine (**2**); (b) protoberberines: palmatine (**3**); (c) aporphines: (−)-asimilobine (**4**), (−)-norannuradhapurine (**5**), (−)-crebanine (**6**), (−)-calycinine (**7a**), (−)-anolobine (**8**), (−)-xylopine (**9**) and (−)-anonaine (**10a**); (d) oxoaporphines: oxocrebanine (**11**) and liriodenine (**12**); (e) phenanthrenes: atherosperminine (**13**), *N*-noratherosperminine (**14**) and *N*-methylatherosperminium (**15**); (f) morphinandienone: (+)-*O*-methylflavinantine (**16**) and (g) unknown bases: FGA and FGB.

The tetrahydroprotoberberine and protoberberine alkaloids, tetrahydropalmatine (**2**) and palmatine (**3**) were identified by direct comparison (mp, mmp, UV, IR, ^{1}H NMR) with authentic samples, respectively. (−)-Discretamine (**1**) was readily identified by its spectral data (UV, IR, ^{1}H NMR and MS) with those in the literature [4–6]. Moreover, O-methylation of (−)-discretamine (**1**) with diazomethane gave (−)-tetrahydropalmatine (**2**) which was identified by comparison with an authentic sample. The ^{13}C NMR spectral data of (−)-discretamine (**1**) was also used to confirm the identification.

In the aporphine alkaloids, (−)-asimilobine (**4**), (−)-crebanine (**6**) and (−)-xylopine (**9**) (main base of *F. oldhamii*) were identified by direct comparison (mmp, TLC and IR) with authentic samples, respectively. In addition, the chemical and physical properties of (−)-



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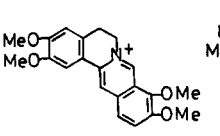
2 R=Me



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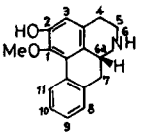

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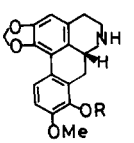

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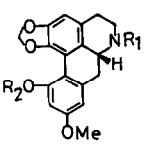
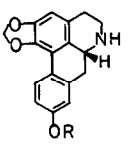


7a $R_1 = R_2 = H$
7b $R_1 = Me, R_2 = H$
7c $R_1 = R_2 = Me$
7d $R_1 = H$, R_2 = 



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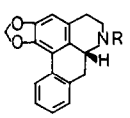
9 R=Me



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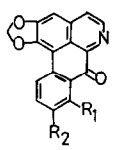
10b R=Me



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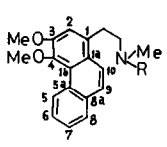
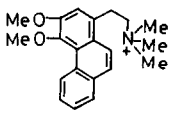
12 R_1=R_2=H



13 R=Me
14 R=H



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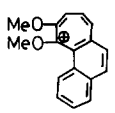
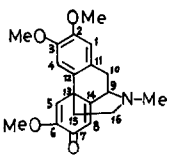


15a m/z 251



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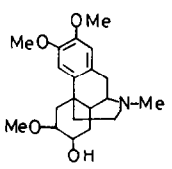

16a

norannuradhapurine (**5**), (−)-anolobine (**8**) and (−)-anonaine (**10a**) agreed with the reported data [7–9], respectively. Moreover, O-methylation of both (−)-norannuradhapurine (**5**) and (−)-anolobine (**8**) with diazomethane gave (−)-crebanine (**6**) and (−)-xylopine (**9**) which were identified by comparison with authentic samples, respectively. N-Methylation of (−)-anonaine (**10a**) with formaldehyde and sodium borohydride afforded (−)-roemerine (**10b**) identical with an authentic sample. The structure of (−)-calycinine (**7a**) [10] {(−)-fissoldine [11], fissistigine A [12, 13]} were determined by spectral data (UV, IR, ^{1}H NMR and MS) and the dehydroxylation product coincided with (−)-xylopine (**9**).

The oxoaporphine alkaloids, oxocrebanine (**11**) (the first time isolated from annonaceous plants and the second time from nature [14]) and liriodenine (**12**) were identified by comparison with authentic samples, respectively.

N-Methylatherosperminium (**15**), $C_{21}H_{26}NO_2^+$ ([M]$^+$, *m/z* 324), was isolated as greyish-white needles mp 238–240° (EtOH) and $[\alpha]_D^{24}$ ±0° (Me_2CO, *c* 0.1). The spectral data [IR ν_{max}^{KBr} cm^{-1}: 1580 (phenyl); UV λ_{max}^{EtOH} nm: 216, 235, 258, 306, 344 and 364 and mass spectral ion *m/z* 251 (**15a**) afforded by the loss of a $[CH_2NMe_3]^+$ fragment suggested a phenanthrene skeleton [15]. In the ^{1}H NMR spectrum (100 MHz, DMSO-d_6), the chemical shifts of three N–Me groups [δ3.37 (3H × 3, *s*)], two methoxyl groups at C-3 and C-4 [δ3.90 and 4.08 (each 3H, *s*), and the seven aromatic protons at H-2 [δ7.59 (1H, *s*)], H-6, H-7, H-8, H-9 and H-10 [δ7.70–7.80 (5H, *m*)] and H-5 [δ9.60 (1H, *m*)] gave support to the 3,4-dimethoxylated quaternary phenanthrene structure, which was also in full agreement with the ^{13}C NMR data of *N*-methylatherosperminium (**15**). The *N*-methylatherosperminium iodide with mp 282–284° (EtOH) was identified by comparison (mp, IR, TLC and ^{1}H NMR) with authentic atherosperminine (**13**) methiodide.

The quaternary phenanthrene alkaloid, *N*-methylatherosperminium (**15**) was firstly isolated, together with atherosperminine (**13**) (main base of *F. glaucescens*) and *N*-noratherosperminine (**14**). The chemical and physical properties of both **13** and **14** agreed with reported data [16, 17], respectively. Moreover, *N*-methylation of **14** with formaldehyde and sodium borohydride gave atherosperminine (**13**) which was identified by comparison with an authentic sample.

The morphinandienone alkaloid, (+)-*O*-methylflavinantine (**16**) (*O*-methylpallidine [18]) was identified by comparison (mmp, TLC and IR) with an authentic sample. In addition, the catalytic hydrogenation of *O*-methylflavinantine (**16**) with PtO or Pd–C catalyst afforded a cyclohexanolic morphinandienone, hexahydro-*O*-methylflavinantine (**16a**) with mp 75–77° (Me_2CO), $C_{20}H_{29}NO_4$ (*m/z* 347) and $[\alpha]_D^{24}$ +30°. In the mass spectrum of hexahydro-*O*-methylflavinantine (**16a**), there is a characteristic intense fragment at *m/z* 59 ($CH_3NHCH_2CH_3$) which indicates that the B/C ring junction has a *trans*-configuration [19, 20]. Moreover, the ^{13}C NMR spectrum of *O*-methylflavinantine (**16**) was also assigned.

The alkaloids isolated from the three Taiwan species are summarized in Table 1.

EXPERIMENTAL

General. Mps are uncorr. NMR spectra were recorded at 60 or 100 MHz with TMS as int. standard and chemical shifts were recorded in δ (ppm) units. Mass spectra were measured using a double focussing instrument. Silica gel (60–120 mesh) (Merck) and neutral alumina (Merck) were used for CC and silica gel GF-254 for TLC.

Bark and wood of the stem of *F. glaucescens* (Hance) Merr. were collected in Mt Nan-Jien, Pingtung-Hsien, Taiwan, in January, 1983. Air dried plant material, bark (17 kg) and wood (11 kg), was extracted with warm MeOH. The MeOH solns were concd under red pres to leave a dark brownish viscous residue The bases in the MeOH extracts were extracted with 3% HOAc. The HOAc solns of the total bases were basified with NH_4OH and extracted with CH_2Cl_2. The aq. mother liquors were acidified with HCl The 4° base chloride (part A) was obtained by the route reineckate → sulphate → chloride from the HCl soln The CH_2Cl_2 soln of the 3° bases was shaken with 2% NaOH to yield the phenolic base part B and then extracted with 2% H_2SO_4. The H_2SO_4 soln was basified with NH_4OH and extracted with Et_2O, then the NH_4OH alkali mother liquor was shaken with CH_2Cl_2 to afford part C. The Et_2O extract was shaken with 2% NaOH to separate the nonphenolic base part D and the phenolic base part E.

(−)-*Discretamine* (**1**). Part B (2.54 g from the wood extract, 2 24 g from bark) crystallized in contact with Me_2CO as light grayish needles mp 234–238° (EtOH) (lit. 232°) [4], $[\alpha]_D^{24}$ −284° (EtOH, *c* 0.1) (lit 283°) [4], ^{1}H NMR and MS 70 eV, *m/z* 327 [M]$^+$ as in refs [4, 5]; ^{13}C NMR (25 0 MHz, $CDCl_3$): δ 123.56 (*d*, C-1), 128.18 (*s*, C-1a), 59.09 (*d*, C-1b), 146.08 (*s*, C-2), 147.25 (*s*, C-3), 109.28 (*d*, C-4), 128.36 (*s*, C-4a), 28.49 (*t*, C-5), 35.98 (*t*, C-6), 51 25 (*t*, C-8 or C-13), 125.78 (*s*, C-8a), 144 74 (*s*, C-9), 143.33 (*s*, C-10), 114.90 (*d*, C-11), 114.90 (*d*, C-12), 125 78 (*s*, C-12a), 53.71 (*t*, C-13 or C-8), 59 26 (*q*, C-2 or C-10 OMe), 55.87 (*q*, C-10 or C-2 OMe). The yields were 121 mg from wood and 148 mg from bark. The OMe derivative with mp 142–144° (MeOH) was identical

Table 1. Alkaloids isolated from *F. glaucescens*, *F. oldhamii* and *G. amuyon*

Alkaloids	*F. glaucescens*		*F. oldhamii*		*G. amuyon*	
	bark	wood	bark	wood	bark	wood
Tetrahydroprotoberbernes						
(−)-Discretamine (1)	+	+	−	−	−	−
(−)-Tetrahydropalmatine (2)	−	−	−	−	+	−
Protoberbernes						
Palmatine (3)	−	−	−	−	+	−
Aporphines						
(−)-Asimilobine (4)	+	−	−	−	−	−
(−)-Norannuradhapurine (5)	+	+	−	+	−	−
(−)-Crebanine (6)	+	+	−	−	−	−
(−)-Calycinine (7a)	−	−	+	−	−	−
(−)-Anolobine (8)	−	−	−	+	−	+
(−)-Xylopine (9)	−	−	+	+	−	−
(−)-Anonaine (10a)	−	−	−	−	−	+
Oxoaporphines						
Oxocrebanine (11)	−	+	−	−	−	−
Liriodenine (12)	−	+	−	−	−	+
Phenanthrenes						
Atherosperminine (13)	−	+	−	−	−	−
N-Noratherosperminine (14)	−	+	−	−	−	−
N-Methylatherosperminium (15)	+	+	−	−	−	−
Morphinandienones						
(+)-*O*-Methylflavinantine (16)	−	−	+	−	−	−
Unknown						
FGA	−	+	−	−	−	−
FGB	−	+	−	−	−	−

(mmp, TLC, IR and ^{1}H NMR) with authentic (−)-tetrahydropalmatine (2) available in our laboratory.

(−)-*Asimilobine* (4). The mother liquor obtained by separating (−)-discretamine (1) from part B of bark extract was evapd under red. pres. to leave a light brownish viscous residue. The residue crystallized in contact with Me_2CO as colourless prisms (105 mg), mp 165–167° (Me_2CO) (lit. 177–179°) [21], ^{1}H NMR as in ref. [21]. It was identified by comparison with a ref. sample (mmp, TLC, IR) [21]. Perchlorate: mp 205–208° (EtOH), $[\alpha]_D^{24}$ −114° (EtOH, *c* 0.1).

Oxocrebanine (11). Part C from the wood extract (0.57 g) was placed on an alumina column and eluted with $CHCl_3$ gradually enriched with MeOH. The fractions eluting with $CHCl_3$ provided oxocrebanine (11) as orange-red needles (16 mg), mp 273–275° ($CHCl_3$) (lit. 265–269°) [14], $[\alpha]_D^{24}$ ±0° ($CHCl_3$, *c* 0.1), ^{1}H NMR as in ref. [14]. Identified by comparison with an authentic sample (mmp, TLC, IR) [14].

Atherosperminine (13). A Me_2CO soln of oxalic acid was added to the Me_2CO soln of part D from the wood extract and the mixture was concd under red. pres. to yield a crystalline oxalate as colourless micro needles (9.137 g), mp 201–203° (EtOH), $[\alpha]_D^{24}$ ±0° (EtOH, *c* 0.25). Atherosperminine (13) generated from the oxalate by usual methods was a yellow oily base with ^{1}H NMR as in ref. [16]; ^{13}C NMR (25.0 MHz, $CDCl_3$): δ130.05 (*s*, C-1), 126.07 (*s*, C-1a), 125.20 (*s*, C-1b), 114.84 (*d*, C-2), 162.52 (*s*, C-3 or C-4), 150.80 (*s*, C-4 or C-3), 122.27 (*d*, C-5), 132.74 (*s*, C-5a), 126.48 (*d*, C-6), 126.48 (*d*, C-7), 125.72 (*d*, C-8), 132.74 (*s*, C-8a), 128.06 (*d*, C-9), 128.06 (*d*, C-10), 45.16 (*q* × 2, N–Me × 2), 60.72 (*t*, C-α), 32.18 (*t*, C-β), 56.57 (*q*, C-3 or C-4 OMe), 59.73 (*q*, C-4 or C-3 OMe). Methiodide: colourless needles mp 282–284° (EtOH) (lit. 276–277°) [16]. Perchlorate: colourless needles, mp 204–206° (EtOH) (lit. 201°) [16]. Picrate: dark golden needles, mp 182–185° (EtOH) (lit. 180°) [16]. The oxalate was identified by comparison with authentic atherosperminine oxalate (mmp, TLC and IR) [16].

N-*Noratherosperminine* (14). The mother liquor obtained by separation of atherosperminine oxalate was basified with NH_4OH and extracted with $CHCl_3$. The $CHCl_3$ soln was dried (K_2CO_3) and evapd to leave a brownish viscous residue. The residue was placed on a silica gel column and eluted with $CHCl_3$ gradually enriched with MeOH. The fractions eluting with $CHCl_3$–MeOH (19:1) provided *N*-noratherosperminine (14) as colourless needles (450 mg), mp 181–183° ($CHCl_3$) (lit. 180°) [17], $[\alpha]_D^{24}$ ±0°, ($CHCl_3$, *c* 0.1), ^{1}H NMR as in ref. [17]; ^{13}C NMR (25.0 MHz, DMSO-d_6): δ129.25 (*s*, C-1), 125.39 (*s*, C-1a), 124.21 (*s*, C-1b), 116.02 (*d*, C-2), 150.52 (*s*, C-3 or C-4), 145.49 (*s*, C-4 or C-3), 121.64 (*d*, C-5), 132.36 (*s*, C-5a), 126.68 (*d*, C-6), 126.68 (*d*, C-7), 125.68 (*d*, C-8), 129.26 (*s*, C-8a), 128.20 (*d*, C-9), 127.27 (*d*, C-10), 49.10 (*q*, N–Me), 59.36 (*t*, C-α), 32.46 (*t*, C-β), 56.48 (*q*, C-3 or C-4 OMe), 55.90 (*q*, C-4 or C-3 OMe). The perchlorate of the *N*-methyl derivative mp 204–206° (EtOH) was identified by comparison with authentic atherosperminine perchlorate (mp, TLC and IR).

N-*Methylatherosperminium* (15). (i) The NH_4OH alkali mother liquor obtained by separating the $CHCl_3$ soln of 14 was acidified with 10% HCl. The acidic soln was evapd to dryness under red. pres. The residue was dissolved in EtOH, filtered and evapd under red. pres. The residue was dissolved in $CHCl_3$, filtered and evapd to leave an oily residue which was placed on a silica gel column and eluted with Me_2CO. The Me_2CO soln was concd until *N*-methylatherosperminium (15) was deposited as light grayish white needles (112 mg) mp 238–240° (EtOH); $[\alpha]_D^{24}$

±0° (Me_2CO, *c* 0.1); IR ν_{max}^{KBr} cm^{-1}: 1580 (phenyl); UV λ_{max}^{EtOH} nm (log ε): 216 (4.43), 235 sh (4.46), 258 (4.64), 306 (4.28), 344 (3.42) and 364 (3.42); MS 70 eV, *m/z* (rel. int.): 324 $[M]^+$ (1.00), 323 (3.20), 300 (100), 285 (33.3), 264 (38.6), 257 (18.3), 251 (67.8), 236 (5.37), 208 (18.3), 193 (4.30) and 165 (18.3); ^1H NMR (100 MHz, DMSO-d_6): δ3.37 (9H, *s*, N–Me × 3), 3.90 and 4.08 (each 3H, *s*, C-3 and C-4 OMe), 7.59 (1H, *s*, H-2), 7.70–7.80 (5H, *m*, H-6, H-7, H-8, H-9 and H-10), 9.60 (1H, *m*, H-5); ^{13}C NMR (25.0 MHz, DMSO-d_6): δ129.24 (*s*, C-1), 125.50 (*s*, C-1a), 124.33 (*s*, C-1b), 116.08 (*d*, C-2), 150.77 (*s*, C-3 or C-4), 145.86 (*s*, C-4 or C-3), 122.11 (*d*, C-5), 132.40 (*s*, C-5a), 126.48 (*d*, C-6), 126.48 (*d*, C-7), 128.31 (*d*, C-8), 132.74 (*s*, C-8a), 127.37 (*d*, C-9), 127.37 (*d*, C-10), 52.25, 52.37 and 52.55 (*q* × 3, N–Me × 3), 65.36 (*t*, C-α), 26.16 (*t*, C-β), 56.47 (*q*, C-3 or C-4 OMe), 59.33 (*q*, C-4 or C-3 OMe). Perchlorate: colourless needles, mp 246–249° (EtOH). (Found: C, 59.03; H, 6.08; N, 3.26. $C_{21}H_{26}NO_2^+ClO_4^- \cdot 1/5 \cdot H_2O$ requires: C, 59.00; H, 6.22; N, 3.28%.) Iodide: colourless needles, mp 282–284° (EtOH). The iodide was identified (mmp, TLC and IR) by comparison with authentic (**13**) methiodide. (ii) Part A. The total 4° base chlorides of both bark and wood extracts 9.8 g was dissolved in H_2O (80 ml) and satd with KI. The ppts of base iodides were filtered, dissolved in EtOH and concd under red. pres. to yield crystalline *N*-methylatherosperminium iodide as colourless needles (5.2 g), mp 282–284° (EtOH) which was identified (mmp, TLC and IR) by comparison with *N*-methylatherosperminium iodide obtained from (i).

FGA. The MeOH soln obtained by continuous elution with MeOH in the *N*-methylatherosperminium (**15**) fraction was concd and crystals were deposited These were recrystallized × 2 from EtOH and an uncharacterized alkaloid (48 mg), mp 207–210°, designated FGA was afforded.

Liriodenine (**12**). Fractions eluting with $CHCl_3$ in the *N*-noratherosperminine (**14**) fraction provided crude liriodenine (**12**) and this was purified by the prep. TLC (silica gel, $CHCl_3$–MeOH, 7:1). When the base of R_f 0.82 obtained by prep. TLC was recrystallized from $CHCl_3$, yellow needles (8 mg), mp 282–284° (lit. 278–280°) [16], $[\alpha]_D^{24}$ ±0° (MeOH, *c* 0.1), ^1H NMR as in ref. [16] was afforded. The alkaloid was identified by comparison with an authentic sample available in our laboratory (mmp, IR and TLC).

FGB. The mother liquor obtained by separating crude liriodenine (**12**) from part D of the wood extract was fractionated by prep. TLC (silica gel, $CHCl_3$–MeOH, 8:1). When the base of R_f 0.72 obtained by prep. TLC was recrystallized from Me_2CO, an uncharacterized alkaloid (5 mg), mp 230–232° and MS 70 eV, *m/z* 365 $[M]^+$, designated FGB was afforded.

(−)-Norannuradhapurine (**5**) Part E [bark (5.335 g) and wood (1.360 g)] dissolved in Me_2CO was treated with HBr and concd under red. pres. to yield the crystalline hydrobromide (510 mg) [bark (118 mg) and wood (393 mg)] as light grayish needles (233 mg) with mp 270–272° (decomp.), $[\alpha]_D^{24}$ −36° (MeOH, *c* 0.1). (−)-Norannuradhapurine (**5**) generated from the HBr by usual methods was an almost colourless oily base with ^1H NMR as in ref. [7]. The OMe derivative with ^1H NMR as in ref. [22] was identical (TLC, IR and ^1H NMR) with authentic (−)-crebanine [22].

(−)-Crebanine (**6**). The mother liquor of (−)-norannuradhapurine HBr was basified with NH_4OH and extracted with $CHCl_3$. The $CHCl_3$ soln was dried (K_2CO_3) and evapd to leave a residue which was fractionated by prep. TLC (silica gel, $CHCl_3$–MeOH, 6:1) for the separation of the base at R_f 0.80. When the base of R_f 0.80 obtained by prep. TLC was purified by neutral alumina CC ($CHCl_3$), an almost colourless amorphous base (13 mg) with $[\alpha]_D^{24}$ −60° ($CHCl_3$, *c* 0.2) (lit. −61°) [22], ^1H NMR as in ref [22] was obtained. This was identified (TLC, IR and ^1H NMR) by comparison with an authentic sample [22].

Bark and wood of the stem of *F. oldhamii* (Hemsl.) Merr. was collected in Wulai, Taipei-Hsien, Taiwan, in December, 1981. Air dried plant material, bark (6.58 kg) and wood (12.05 kg), was extracted using the same method as described for *F. glaucescens*. The HOAc solns of the total bases were basified with NH_4OH and extracted with $CHCl_3$. The $CHCl_3$ soln was shaken with 2% NaOH to yield the phenolic base part A and then extracted with 2% H_2SO_4. The H_2SO_4 soln was basified with NH_4OH and extracted with Et_2O. The Et_2O extract was shaken with 2% NaOH again to separate the phenolic base part B and the nonphenolic base part C. The NH_4OH alkali mother liquor was extracted with $CHCl_3$ to afford part D.

(−)-Calycinine (**7a**). Part A (3.47 g) of the bark extract dissolved in Me_2CO was treated with HBr and concd under red. pres. to yield the crystalline HBr as light grayish needles (1.356 g) mp 276–277° (EtOH). (−)-Calycinine (**7a**) generated from the HBr by usual methods was an almost colourless oily base with $[\alpha]_D^{25}$ −96° (EtOH, *c* 1.0) (lit. −145°) [10], ^1H NMR as in ref. [10], MS 70 eV, *m/z* 311 $[M]^+$. Gibbs test: (+). The NMe derivative (**7b**) had ^1H NMR as in ref. [10] and its hydrobromide had mp 236–239°

O-Methylation of N-*methylcalycinine* (**7b**). To a soln of *N*-methylcalycinine (**7b**) (77 mg), CH_2N_2 in Et_2O (80 ml) was added and the mixture kept for 4 days at room temp. After the mixture was acidified with 3% HOAc, the aq layer was basified with 10% NaOH and extracted with $CHCl_3$. The $CHCl_3$ soln was dried (K_2CO_3) and evapd to give a yellow oily base, *N,O*-dimethylcalycinine (**7c**) (50 mg) with $[\alpha]_D^{24}$ −207° ($CHCl_3$, *c* 0.5) and ^1H NMR (60 MHz, $CDCl_3$): δ2.50 (3H, *s*, NMe), 3.82 (3H, *s*, 9-OMe), 3.86 (3H, *s*, 11-OMe), 5.86 and 6.01 (each 1H, *d*, *J* = 3.0 Hz, 1,2-OCH_2O), 6.49 (2H, *s*, H-3 and H-10) and 6.55 (1H, *s*, H-8).

Dehydroxylation of (−)-calycinine (**7a**) [*preparation of (−)-xylopine* (**9**) *from (−)-calycinine* (**7a**)]. (i) Preparation of 11-(1-phenyl-5-tetrazolyloxy) xylopine (**7d**): 1-phenyl-5-chlorotetrazole (57 mg) and anhydrous K_2CO_3 (100 mg) were added to a soln of (−)-calycinine (**7a**) (92 mg) in Me_2CO (8 ml) and the mixture refluxed for 24 hr at 100°. The mixture was filtered and evapd to dryness under red. pres. The residue was dissolved in 3% HOAc (20 ml), filtered, basified with NH_4OH and extracted with $CHCl_3$. The $CHCl_3$ soln was washed with 2% NaOH, dried (K_2CO_3) and evapd to give a yellow oily product (**7d**) (22 mg). (ii) Hydrogenolysis of 11-(1-phenyl-5-tetrazolyloxy) xylopine (**7d**) [preparation of (−)-xylopine (**9**)]. A mixture of (**7d**) (22 mg) and Pd–C (10%) (20 mg) in EtOH (10 ml) was hydrogenated in a low-pres. quantitative catalytic hydrogenation apparatus at room temp for 9 hr. The catalyst was filtered off and the filtrate evapd under red. pres. The residue was dissolved in 3% HOAc (15 ml), filtered, basified with NH_4OH and extracted with Et_2O. The Et_2O soln was washed with 2% NaOH, dried (K_2CO_3) and evapd to give a light brownish residue which was fractionated by prep. TLC (silica gel, $CHCl_3$–MeOH, 7:1) for the separation of the base at R_f 0.65. When the base of R_f 0.65 obtained by prep. TLC was purified by neutral alumina CC ($CHCl_3$), an almost colourless amorphous base (9 mg) with $[\alpha]_D^{24}$ −50° (EtOH, *c* 0.5) and ^1H NMR as in ref. [23] was afforded. It was identified by comparison with authentic (−)-xylopine (**9**) (TLC, IR and ^1H NMR).

(−)-Norannuradhapurine (**5**). Part A (4.42 g) of the wood extract was treated using the same method as described for *F. glaucescens*. HBr (113 mg), mp 273–275° (decomp) $[\alpha]_D^{24}$ −55° (EtOH, *c* 1.0), and comparison with an authentic sample available from *F. glaucescens* (mmp, IR and TLC).

(−)-Anolobine (**8**). Part B (1.967 g) of the wood extract crystallized in contact with Me_2CO as light grayish prism (466 mg), mp 240–242° (Me_2CO) (lit. 237–241°) [8], $[\alpha]_D^{25}$ −21°

(MeOH, *c* 0.1) (lit. −19°) and ^{1}H NMR as in ref. [8]. The OMe derivative of (**8**) had ^{1}H NMR as (−)-xylopine (**9**), and was identified by comparison with an authentic sample available in our laboratory (IR and TLC). HBr: mp 261–263° (MeOH–EtOH).

(−)-*Xylopine* (**9**). Part C (bark 3.09 g and wood 7.18 g) crystallized in contact with Me_2CO as light grayish brown prisms (6.4 g), mp 107–109° (MeOH) (lit. 124–125°) [23], $[\alpha]_D^{24}$ −54° (EtOH, *c* 1.0) (lit. −23°) [23], ^{1}H NMR as in ref. [23]. Tartrate: mp 184–188° (MeOH–H_2O). It was identified by comparison with authentic xylopine tartrate (mmp, TLC and IR) [24].

(+)-O-*Methylflavinantine* (**16**). Part D (2.07 g) of the bark extract crystallized in contact with Me_2CO. The crystals were purified by neutral alumina CC ($CHCl_3$) and recrystallized × 3 from C_6H_6 to yield (+)-*O*-methylflavinantine (**16**) as colourless prisms (1.221 g) mp 124–125° (lit. 118–120°) [18], $[\alpha]_D^{24}$ +46.5° ($CHCl_3$, *c* 1.0) (lit. +25.2°) [18], ^{1}H NMR as in ref. [18]; ^{13}C NMR (25.0 MHz, $CDCl_3$): δ108.81 (*d*, C-1), 148.42 (*s*, C-2), 151 40 (*s*, C-3), 110.51 (*d*, C-4), 122.15 (*d*, C-5 or C-8), 148.07 (*s*, C-6), 180.89 (*s*, C-7), 118.87 (*d*, C-8 or C-5), 60.90 (*d*, C-9), 41.24 (*t*, C-10), 130.05 (*s*, C-11), 128.82 (*s*, C-12), 42.29 (*s*, C-13), 161.76 (*s*, C-14), 32.70 (*t*, C-15), 45.74 (*t*, C-16), 41.71 (*q*, N–Me), 55.10 (*q*, C-2 OMe), 55.92 (*q*, C-3 OMe) and 56.33 (*q*, C-6 OMe); CD (MeOH): $[\theta]_{265}$ +2.215 × 10^3, $[\theta]_{279}$ −2.555 × 10^3, $[\theta]_{299}$ +1.192 × 10^4, $[\theta]_{336}$ +0.851 × 10^3, $[\theta]_{356}$ +1.192 × 10^3. Methiodide had mp 252–254° (EtOH) (lit. 247–249°) [25]. It was identical (mmp, TLC and IR) with authentic *O*-methylflavinantine [25].

Hexahydro-O-methylflavinantine (**16a**). (i) A mixture of *O*-methylflavinantine (**16**) (30 mg) and PtO_2 (50 mg) in HOAc (28 ml) was hydrogenated in a low-pres. quantitative catalytic hydrogenation apparatus at room temp. for 9 hr. The catalyst was filtered off and the filtrate basified with NH_4OH and extracted with $CHCl_3$. The $CHCl_3$ soln was dried (K_2CO_3) and evapd to give a brownish residue which was fractionated by prep. TLC (silica gel, $CHCl_3$–MeOH, 6:1) for the separation of the base at R_f 0.25. When the base of R_f 0.25 obtained by prep. TLC was purified and recrystallized from Me_2CO, colourless needles (15 mg) were obtained mp 75–77°; $[\alpha]_D^{24}$ +30° (MeOH, *c* 0.1); UV λ_{max}^{EtOH} nm (log ε): 224 sh (4.05), 284 (3.57); ^{1}H NMR (60 MHz, $CDCl_3$): δ2.45 (3H, *s*, NMe), 3.31 (3H, *s*, OMe), 3.92 (6H, *s*, 2 × OMe), 6.65 (1H, *s*, H-1), 6.88 (1H, *s*, H-4); MS 70 eV, *m/z* (rel. int.): 347 $[M]^+$ (100), 332 (6.20), 316 (2.10), 288 (10.30), 270 (3.10), 256 (4.13), 196 (36.01) and 59 (67.01) afforded. (ii) A mixture of **16** (50 mg) and Pd–C (90 mg) in MeOH (10 ml) was hydrogenated using the same method as described in part (i) above for 3 hr. The catalyst was filtered off and the filtrate evapd under red. pres. The residue was dissolved in 3% HOAc (30 ml), filtered, basified with NH_4OH and extracted with $CHCl_3$. The $CHCl_3$ soln was dried (K_2CO_3) and evapd to give a brownish residue which was treated by the same procedure as described in part (i). Colourless needles (25 mg), mp 75–77° which were identical (TLC, IR and ^{1}H NMR) with authentic hexahydro-*O*-methylflavinantine (**16a**) obtained as in part (i) were afforded.

Bark and wood of the stem of *G. amuyon* (Blanco) Merr. were collected in Hengchun, Pingtung, Hsien, Taiwan, in December, 1982. Air dried plant material, bark (2.7 kg) and wood (4.8 kg), were extracted using the same method as described for *F. glaucescens*. The acidic solns were filtered, basified with NH_4OH and extracted with $CHCl_3$. The $CHCl_3$ solns were shaken with 2% aq. NaOH to separate the phenolic and nonphenolic bases, respectively.

(−)-*Tetrahydropalmatine* (**2**) The nonphenolic base part of the bark extract (700 mg) was placed on a silica gel column. Elution was with $CHCl_3$ gradually enriched with MeOH. The fractions eluting with $CHCl_3$–MeOH (100:1) provided (−)-tetrahydropalmatine (**2**) as colourless needless (21 mg) mp 125–127° (MeOH) (lit. 141–142°) [26], $[\alpha]_D^{24}$ −284° (MeOH, *c* 0.1) (lit. −290°) [26]. Identification was by comparison with an authentic sample available in our laboratory (mmp, IR, TLC and ^{1}H NMR).

Palmatine (**3**). Continuous elution with $CHCl_3$–MeOH (1:10) of the former nonphenolic base part of the bark extract afforded palmatine (**3**) as yellow needles (4 mg) mp 202–204° (Me_2CO) (lit. 203–204°) [26], $[\alpha]_D^{24}$ ±0° (MeOH, *c* 0.08), which was identified by comparison with an authentic sample available in our laboratory (mmp, UV, IR and TLC).

(−)-*Anolobine* (**8**). The phenolic base part of the wood extract (400 mg) crystallized in contact with Me_2CO as light grayish prism (30 mg) mp 240–242° (Me_2CO). **8** was identified by comparison with an authentic sample available from *F. oldhamii* (IR, TLC and ^{1}H NMR).

Liriodenine (**12**). The nonphenolic base part of the wood extract (800 mg) was placed on a silica gel column. Elution was with $CHCl_3$ gradually enriched with MeOH. The fractions eluting with $CHCl_3$–MeOH (50:1) provided crude liriodenine (**12**), which was fractionated by prep. TLC (silica gel, $CHCl_3$–MeOH, 7:1) for the separation of the base at R_f 0.85. When the base of R_f 0.85 obtained by prep. TLC was purified by neutral alumina CC ($CHCl_3$), yellow needles (15 mg) of liriodenine (**12**) mp 281–283° were afforded. Identification was by comparison with an authentic sample available from *F. glaucescens* (mmp, IR, TLC and ^{1}H NMR).

(−)-*Anonaine* (**10a**). The residue of the fractions eluting with $CHCl_3$–MeOH (25:1) in the former nonphenolic base part was dissolved in Me_2CO, treated with HBr, and concd under red. pres. to yield crystalline HBr as light grayish needles (9 mg), mp 283–285° (MeOH), $[\alpha]_D^{24}$ −45.6° (MeOH, *c* 0.1) (lit. −68°) [9]. Anonaine (**10a**) generated from the HBr by usual methods was an almost colourless oily base with ^{1}H NMR as in ref. [9]. The N–Me derivative (**10b**) had ^{1}H NMR as in ref. [23], the hydrochloride had mp 245–248° (MeOH) and was identified by direct comparison (mp, TLC and IR) with authentic roemerine hydrochloride.

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