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Studies on Constituents of Crude Drugs. XV.[1] New Pyrrolizidine Alkaloids from *Ligularia dentata*

YOSHIHISA ASADA and TSUTOMU FURUYA*

School of Pharmaceutical Sciences, Kitasato University, 5-9-1 Shirokane, Minato-ku, Tokyo 108, Japan

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Four new pyrrolizidine alkaloids, ligularidine, neoligularidine, ligularizine and ligularinine, were isolated together with the known compound clivorine from the roots and aerial parts of *Ligularia dentata*. Their structures were elucidated on the basis of the spectral data and chemical conversion of clivorine into these alkaloids. A useful epoxidation of pyrrolizidine alkaloids was achieved by using performic acid.

Keywords——*Ligularia dentata*; Compositae; pyrrolizidine alkaloid; ligularidine; neoligularidine; ligularizine; ligularinine; clivorine; epoxidation; chemical conversion

In a preliminary communication,[2] we reported the isolation of a new macrocyclic pyrrolizidine alkaloid, named ligularidine, from *Ligularia dentata* HARA (Japanese name: Maruba-dakebuki), the young plants of which are used as a food in rural areas in Japan. The presence of sesquiterpenes[3] and pyrrolizidine alkaloids[4] in this plant has already been reported. This paper describes the structure determination and chemical conversion of new pyrrolizidine alkaloids isolated from *Ligularia dentata*. The crude alkaloids obtained from the methanolic extracts of the roots and aerial parts were chromatographed on a silica gel column with C_6H_6 : AcOEt : Et_2NH as a solvent system to give five alkaloids, *i.e.*, four new alkaloids (**2**), (**3**), (**4**), and (**5**) together with a known alkaloid, clivorine (**1**). The yields of alkaloids obtained from the roots and aerial parts are shown in Table I.

Alkaloid I (**1**), the main alkaloid, was obtained as colorless prisms (ether), mp 149—150 °C, $[\alpha]_D^{27}$ +80°, $C_{21}H_{27}NO_7$ and identified as clivorine by mixed fusion, $[\alpha]_D$ and infrared (IR) spectral comparison with an authentic sample.

Alkaloid II (**2**), named ligularidine, was obtained as colorless needles (ether), mp 196 °C, $[\alpha]_D^{28}$ −49.8°, $C_{21}H_{29}NO_7$. The IR spectrum of **2** shows absorptions at 1740 and 1730 (acetyl and ester carbonyl), 1700 (conjugated ester carbonyl) and 1610 cm^{-1} ($\overset{\delta+}{\text{N}}\cdots\text{C}=\overset{\delta-}{\text{O}}$). The molecular ion peak at *m/z* 407 in its mass spectrum (MS) suggests the introduction of two additional hydrogen atoms into **1**, and other prominent peaks at *m/z* 168, 151, 110 and 96 indicate that **2** is a macrocyclic diester of otonecine. The proton nuclear magnetic resonance (^{1}H-NMR) spectrum of **2** also shows a typical macrocyclic diester pattern of otonecine[5] and is similar to that of clivorine (**1**). In the ^{1}H-NMR spectrum of **2**, the signals of the vinyl group at C-15 in **1** had disappeared and the signals of an ethylidene group at C-15 appeared as follows: δ 1.78 (3H, d, J=8 Hz) for vinyl methyl protons at C-21 and δ 6.79 (1H, q, J=8 Hz) for an olefinic proton at C-20.

Alkaloid III (**3**), named neoligularidine, was obtained as colorless needles (*n*-hexane), mp 117—119 °C, $[\alpha]_D^{27}$ −58°, $C_{21}H_{29}NO_7$. The mass spectrum of **3** shows the same molecular ion peak at *m/z* 407 as that of **2**, and the fragmentation is similar to that of **2**. The ^{1}H-NMR spectrum of **3** shows a doublet at δ 1.92 ppm corresponding to vinyl methyl protons at C-21 and a quartet at δ 5.87 due to an olefinic proton at C-20. The difference in the olefinic proton

Table I. Alkaloids Isolated from *Ligularia dentata*

Alkaloid	Aerial parts (17.7 kg)	Roots (8.8 kg)
Clivorine (**1**)	0.13%	0.26%
Ligularidine (**2**)	0.0018%	0.003%
Neoligularidine (**3**)	0.0002%	
Ligularizine (**4**)	0.006%	0.011%
Ligularinine (**5**)		0.004%

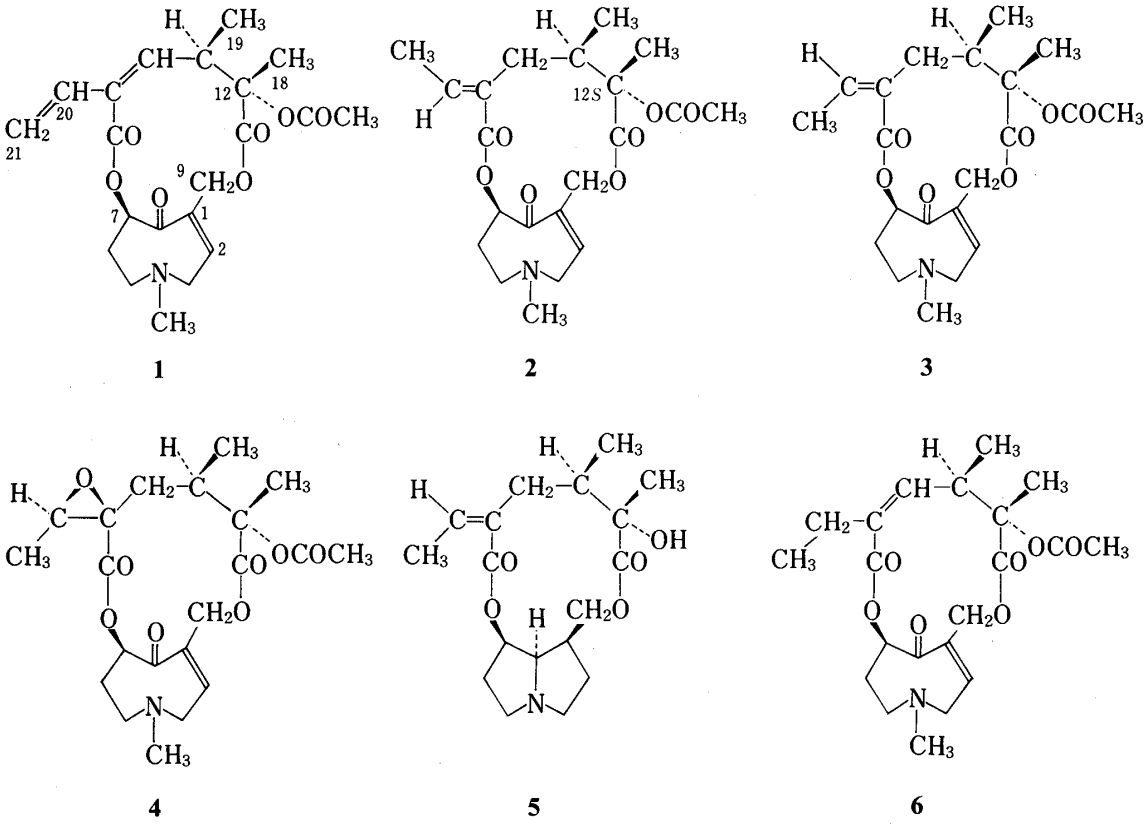


Chart 1

chemical shifts value between **2** and **3** is 0.92, which suggests that **3** is the *Z* isomer of **2**.[6]

In order to confirm the structures of **2** and **3**, **1** was catalytically reduced with Pd-C to give **2**, **3** and **6** (Chart 2). From the spectral data and chemical transformation mentioned above, the structures of ligularidine and neoligularidine were determined as **2** and **3**, respectively.

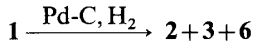


Chart 2

Alkaloid IV (**4**), named ligularizine, was isolated as the picrate, yellow needles, mp 210—211 °C (picrate, ethanol), $[\alpha]_D^{25}$ −24.5°, $C_{21}H_{29}NO_8 \cdot C_6H_3N_3O_7$. The MS of **4** shows a molecular ion peak at *m/z* 423 which is larger by 16 mass units than that of **2** or **3**, and other prominent peaks indicate that **4** is an epoxide of **2** or **3** (Chart 3). The ^{1}H-NMR spectrum of **4** is similar to that of **3**. The signals of the olefinic proton at C-20 and vinyl

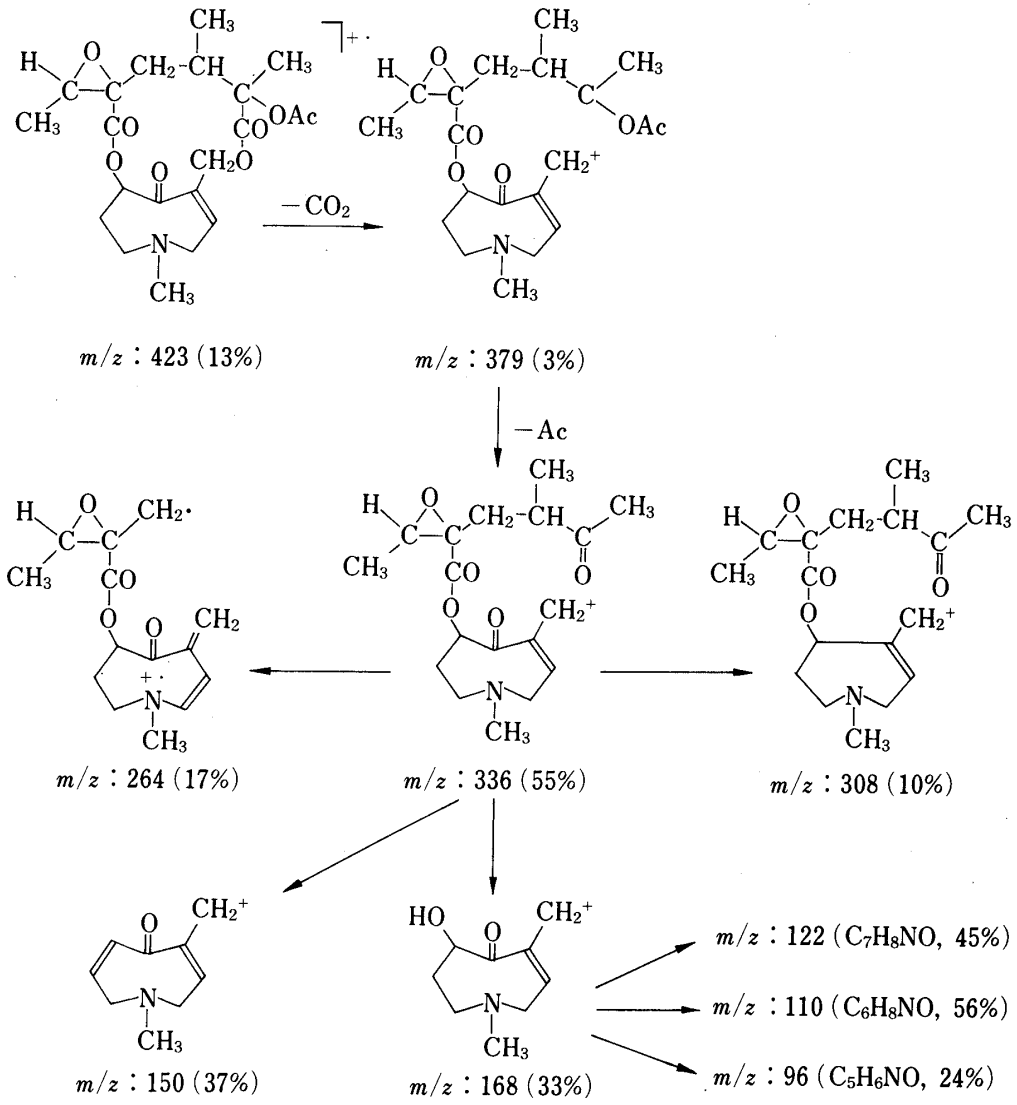


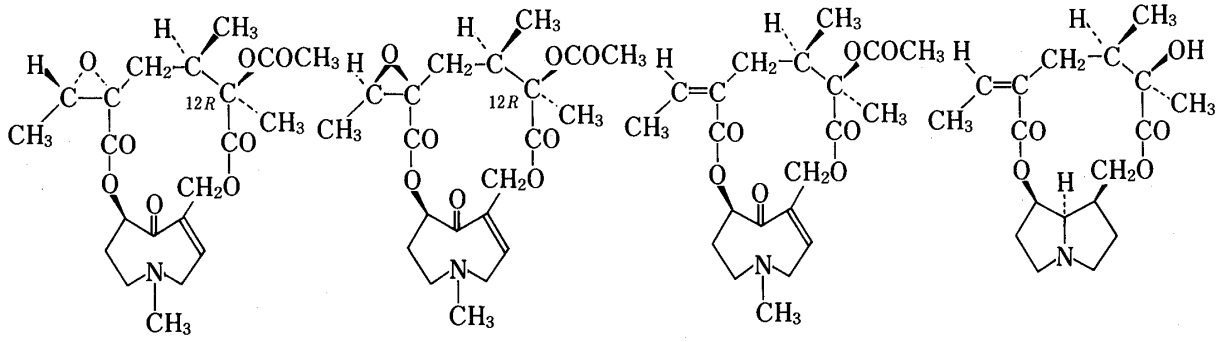
Chart 3

methyl protons at C-21 in **3** had disappeared and the signals of an epoxide methine proton δ 3.00 (1H, q, $J=6$ Hz) at C-20 and methyl protons δ 1.47 (3H, d, $J=6$ Hz) at C-21 appeared in **4**. Therefore the structure of **4** was presumed to be the 15,20-epoxide of **2** or **3**. The ^{1}H-NMR spectral data for florosenine (**7**),[7] acetylfukinotoxin (**8**),[8] and ligularizine (**4**), each containing a 15,20-epoxide group, are shown in Table II. From a comparison of chemical shift values at C-20 and C-21 in the ^{1}H-NMR spectra, ligularizine (**4**) was supposed to be the β-epoxide of neoligularidine (**3**). The carbon-13 nuclear magnetic resonance (^{13}C-NMR) spectral data for ligularizine (**4**) and acetylfukinotoxin (**8**) are shown in Table III. The chemical shift values of **4** are similar to those of **8** except for the chemical shift value at C-18. The ^{13}C-NMR spectral data suggest that **4** is an epimer of **8** at C-12.[9] In order to confirm the structure of ligularizine (**4**), the chemical transformation of neoligularidine (**3**) to **4** was performed by epoxidation with performic acid. We have already observed that acetylfukinotoxin (**8**), which is a β-epoxide, was mainly obtained on oxidizing acetylsenkirkine (**9**) with performic acid.[10] From the spectral data and chemical transformation mentioned above, the structure of ligularizine was determined to be **4**.

Alkaloid V (**5**), named ligularinine, was obtained as colorless prisms (ether), mp 103—104 °C, $[\alpha]_D^{24}$ −88 °, $C_{18}H_{27}NO_5$. The MS of **5** shows a molecular ion peak at m/z 337 and its fragmentation is similar to that of platyphylline (**10**).[11] This suggests that ligularinine (**5**) has

TABLE II. ^{1}H-NMR Spectral Data for **7**, **8** and **4**

Compound	C_{20}–H	C_{21}–H
Florosenine (**7**)	2.95	1.24 (α-Epoxide)
Acetylfukinotoxin (**8**)	3.02	1.46 (β-Epoxide)
Ligularizine (**4**)	3.00	1.47 (β-Epoxide)



7 **8** **9** **10**

Chart 4

TABLE III. ^{13}C Chemical Shifts and Assignments[a)]

Carbon	**4**	**8**	Carbon	**4**	**8**
1	133.5	133.3	14	36.9	37.0
2	138.3	138.7	15	62.2	62.6
3	63.7	64.1	16	166.0	166.3
5	53.2	53.1	18	14.4	21.5
6	35.8	36.5	19	13.9	13.0
7	77.4	77.3	20	61.4	61.4
8	190.2	190.0	21	15.5	15.6
9	58.9	58.9	N–CH_3	40.1	40.0
11	171.2	170.5	$-\overset{\overset{O}{\|}}{C}-CH_3$	169.6	169.6
12	82.8	83.4		21.0	21.4
13	36.3	38.4			

a) Chemical shifts in ppm downfield from tetramethylsilane (TMS); solvent $CDCl_3$.

TABLE IV. ^{13}C Chemical Shifts and Assignments[a)]

Carbon	**5**	**10**	Carbon	**5**	**10**
1	40.3	39.5	12	77.1	75.7
2	29.6	31.7	13	39.4	37.3
3	54.7	53.5	14	38.9	39.2
5	52.5	51.8	15	131.8	131.7
6	34.8	35.8	16	167.2	167.5
7	75.1	74.1	18	17.9	26.1
8	68.9	69.4	19	13.4	13.5
9	64.1	66.6	20	135.9	135.8
11	175.0	178.5	21	15.4	15.5

a) Chemical shifts in ppm downfield from TMS; solvent $CDCl_3$.

the same plane structure as platyphylline (**10**). The ^{1}H-NMR spectrum shows a typical pattern of a macrocyclic diester of platynecine (**11**) and is similar to that of **10**. As shown in Table IV, the ^{13}C-NMR spectral data for **5** and **10** suggest that **5** is an epimer of **10** at C-12. Hydrolysis of ligularinine (**5**) afforded platynecine (**11**) and necic acid (**12**), which was identical with **12** obtained from the hydrolysis of neoligularidine (**3**) (Chart 5). From the spectral data and chemical study mentioned above, the structure was determined to be **5**.

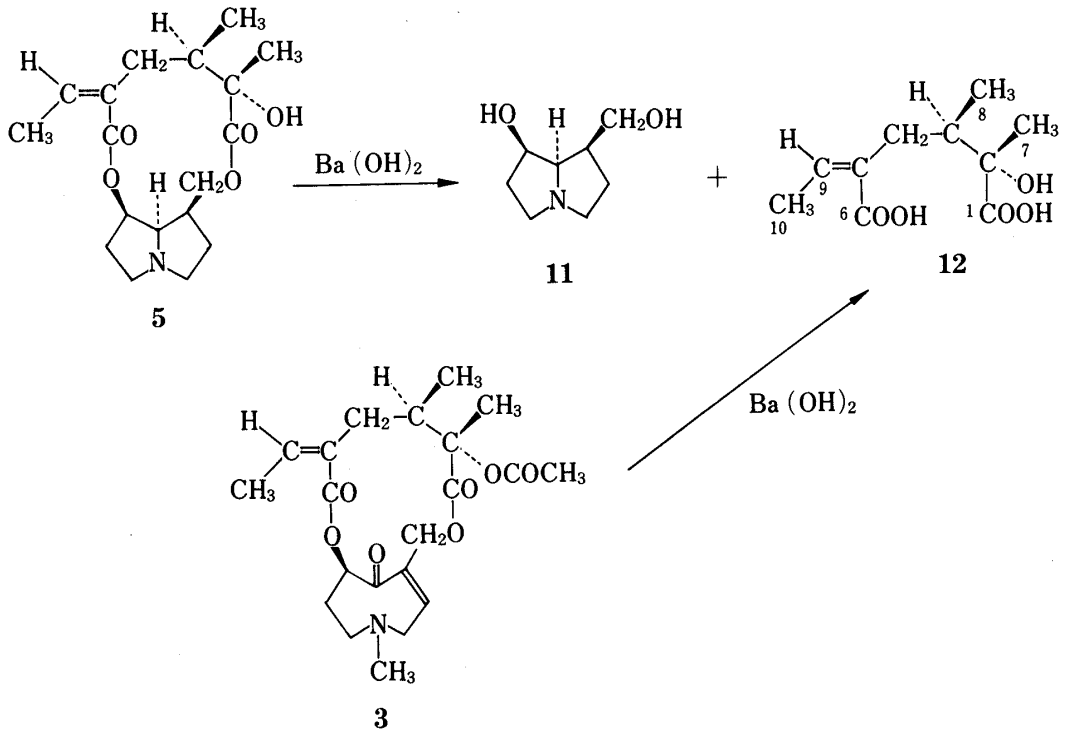


Chart 5

In conclusion, the structures of **2**, **3** and **4** were determined by spectral analysis and chemical correlation with **1**. The structure of **5** was also determined by spectral analysis and hydrolysis. The successful transformation of **3** to **4** using performic acid was carried out and it was demonstrated that performic acid oxidation is useful in compounds of this type to synthesize β-epoxides. The presence of **1**, **2**, **3**, **4** and **5** having 12*S* configuration in *Ligularia dentata* is interesting in comparison with that of **8**, **10** and senecionine having 12*R* configuration in *Ligularia japonica*[8] from chemotaxonomical and biosynthetic viewpoints. Further, it is known that some macrocyclic secopyrrolizidine alkaloids such as fukinotoxin[12] and clivorine (**1**)[13] are carcinogenic. Therefore tests for carcinogenicity, mutagenicity and other biological activities of the present compounds are in progress.

Experimental

Melting points were determined on a Büchi melting point apparatus and are uncorrected. IR spectra were recorded on Shimadzu IR 27G and JASCO IRA-I spectrometers. ^{1}H-NMR and ^{13}C-NMR spectra were taken on a JEOL PS 100 Fourier-transform spectrometer and chemical shifts are given on the δ (ppm) scale with tetramethylsilane as an internal standard. High resolution mass spectra were obtained with JEOL JMS-01SG and DX-300 mass spectrometers.

Extraction of Crude Alkaloids——The air-dried powdered aerial parts and roots of *Ligularia dentata* collected in Izu-kogen, Shizuoka Pref., were extracted with MeOH three times. The MeOH extract obtained from the aerial parts (17.7 kg) was extracted with 0.5 N H_2SO_4 several times. The acid-soluble fraction was extracted with $CHCl_3$ three

times. The aqueous acidic solution was then made alkaline with 28% NH_4OH and extracted with $CHCl_3$ six times to give 50 g of crude alkaloid. The MeOH extract obtained from the roots (8.8 kg) was extracted with 0.5 N H_2SO_4 several times. The acid-soluble fraction was extracted with $CHCl_3$ three times. The aqueous acidic solution was reduced with zinc dust and 18 N H_2SO_4 was added to make the solution 2 N with respect to acid. The aqueous acid solution was filtered, made alkaline with 28% NH_4OH and extracted with $CHCl_3$ six times to give 60.1 g of crude alkaloid.

Separation of Alkaloids——The crude alkaloid (50 g) obtained from the aerial parts was extracted with hot *n*-hexane : AcOEt = 1 : 1 and the residue obtained after evaporating off the solvent was recrystallized from ether to afford **1** (14.7 g). The residue (31.3 g) obtained from the mother liquor was subjected to silica gel (1.5 kg) column chromatography. On elution with a mixed solvent, C_6H_6 : AcOEt : Et_2NH = 72 : 20 : 8, **2** (209 mg), **4** (818 mg as the picrate) and **1** (7.92 g) were obtained in fractions 22—24, 26—29 and 30—81, respectively. The mixed alkaloid fractions (22—81) were chromatographed repeatedly on a silica gel column (solvent; C_6H_6 : AcOEt : Et_2NH = 75 : 20 : 5) and **2** (110 mg), **4** (874 mg as picrate) and **1** (736 mg) were obtained. Furthermore, a fraction consisting mainly of **3** was purified by semipreparative high performance liquid chromatography (HPLC) on a μ-Porasil column (solvent; CH_3CN : $CHCl_3$: MeOH : Et_2NH = 300 : 300 : 6 : 1.6, flow rate; 2 ml/min) to give **3** (34.5 mg) after recrystallization from *n*-hexane. The crude alkaloid (60.1 g) obtained from the roots was extracted with hot *n*-hexane : AcOEt = 1 : 1 and the residue obtained after evaporating the solvent was recrystallized from ether to afford **1** (14.6 g). The purified residue (33.4 g) obtained from the mother liquor was subjected to silica gel (1.5 kg) column chromatography, and elution with a mixed solvent C_6H_6 : AcOEt : Et_2NH = 70 : 20 : 10 gave **2** (200 mg), **4** (1.361 g as the picrate) and **1** (7.25 g) in fractions 16—18, 20—22 and 23—40, respectively. The residue obtained from the mother liquor of **1** was extracted with hot *n*-hexane and the residue obtained after evaporating the solvent was recrystallized from ether to afford **5** (371 mg). The mixed alkaloid fractions (16—40) were chromatographed repeatedly on a silica gel column to give **2** (61 mg), **4** (170 mg as the picrate) and **1** (640 mg).

Clivorine (1): Colorless prisms, mp 149—150 °C (ether), $[\alpha]_D^{27}$ +80.2° (c = 0.99, $CHCl_3$). *Anal.* Calcd for $C_{21}H_{27}NO_7$: C, 62.21; H, 6.71; N, 3.43. Found: C, 62.48; H, 6.83; N, 3.57. IR ν_{max}^{KBr} cm^{-1}: 1748, 1735, 1612. MS *m/z* (%): 405 (M^+, 7), 361 ($M^+ - CO_2$, 3), 318 (9), 168 (19), 151 (27), 150 (17), 96 (5), 94 (15), 43 (100). ^{1}H-NMR ($CDCl_3$) δ: 1.18 (3H, d, J = 6 Hz, C_{19}–H), 1.51 (3H, s, C_{18}–H), 2.04, 2.07 (each 3H, s, N–CH_3, O–CO–CH_3), 2.84 (1H, dq, J = 11, 6 Hz, C_{13}–H), 4.26 (1H, br d, J = 11 Hz, C_9–Ha), 4.99 (1H, d, J = 17 Hz, C_{21}–Ha), 5.03 (1H, d, J = 11 Hz, C_9–Hb), 5.15 (1H, d, J = 10 Hz, C_{21}–Hb), 5.19 (1H, m, C_7–H), 5.38 (1H, d, J = 11 Hz, C_{14}–H), 5.99 (1H, br s, C_2–H), 6.26 (1H, dd, J = 17, 10 Hz, C_{20}–H).

Ligularidine (2): Colorless needles, mp 196 °C (ether), $[\alpha]_D^{28}$ −49.8° (c = 1.02, EtOH). *Anal.* Calcd for $C_{21}H_{29}NO_7$: C, 61.90; H, 7.17; N, 3.44. Found: C, 61.85; H, 7.05; N, 3.27. IR ν_{max}^{KBr} cm^{-1}: 1740, 1730, 1700, 1610. MS *m/z* (%): 407 (M^+, 7), 379 ($M^+ - CO$, 2), 363 ($M^+ - CO_2$, 3), 320 (17), 303 (17), 249 (62), 221 (21), 168 (20), 166 (19), 153 (62), 151 (15), 110 (40), 96 (17), 94 (18), 43 (100). ^{1}H-NMR ($CDCl_3$) δ: 0.94 (3H, d, J = 6 Hz, C_{19}–H), 1.45 (3H, s, C_{18}–H), 1.78 (3H, d, J = 8 Hz, C_{21}–H), 2.00, 2.11 (each 3H, s, N–CH_3, O–CO–CH_3), 4.38 (1H, br d, J = 12 Hz, C_9–Ha), 4.92 (1H, t, J = 5 Hz, C_7–H), 5.11 (1H, d, J = 12 Hz, C_9–Hb), 6.16 (1H, br s, C_2–H), 6.79 (1H, q, J = 8 Hz, C_{20}–H).

Neoligularidine (3): Colorless needles, mp 117—119 °C (*n*-hexane), $[\alpha]_D^{27}$ −58° (c = 0.13, $CHCl_3$). *Anal.* Calcd for $C_{21}H_{29}NO_7$: C, 61.90; H, 7.17; N, 3.44. Found: C, 62.14; H, 7.22; N, 3.47. IR ν_{max}^{KBr} cm^{-1}: 1735, 1725, 1700, 1610. MS *m/z* (%): 407 (M^+, 9), 320 (15), 303 (21), 249 (27), 221 (16), 168 (15), 166 (26), 153 (64), 110 (42), 84 (29), 83 (26), 43 (100). ^{1}H-NMR ($CDCl_3$) δ: 0.96 (3H, d, J = 7 Hz, C_{19}–H), 1.40 (3H, s, C_{18}–H), 1.92 (3H, dd, J = 7.5, 2 Hz, C_{21}–H), 2.01, 2.07 (each 3H, s, N–CH_3, O–CO–CH_3), 4.32 (1H, br d, J = 11.5 Hz, C_9–Ha), 4.94 (1H, t, J = 3.5 Hz, C_7–H), 5.17 (1H, d, J = 11.5 Hz, C_9–Hb), 5.87 (1H, q, J = 7.5 Hz, C_{20}–H), 6.16 (1H, br s, C_2–H).

Ligularizine (4): Yellow needles (picrate), mp 210—211 °C, $[\alpha]_D^{25}$ −24.5° (c = 1.08, $CHCl_3$, picrate). *Anal.* Calcd for $C_{21}H_{29}NO_8 \cdot C_6H_3N_3O_7$: C, 49.70; H, 4.94; N, 8.54. Found: C, 49.76; H, 4.92; N, 8.47. IR (picrate) ν_{max}^{KBr} cm^{-1}: 1745, 1735. MS *m/z* (%): 423 (M^+, 13), 379 ($M^+ - CO_2$, 3), 336 (55), 319 (14), 308 (10), 304 (22), 264 (17), 250 (36), 238 (15), 168 (33), 150 (37), 122 (45), 110 (56), 96 (24), 94 (28), 43 (100). ^{1}H-NMR ($CDCl_3$) δ: 1.10 (3H, d, J = 7 Hz, C_{19}–H), 1.38 (3H, s, C_{18}–H), 1.47 (3H, d, J = 6 Hz, C_{21}–H), 2.02, 2.06 (each 3H, s, N–CH_3, O–CO–CH_3), 3.00 (1H, q, J = 6 Hz, C_{20}–H), 4.26 (1H, br d, J = 12.5 Hz, C_9–Ha), 5.08 (1H, br s, C_7–H), 5.23 (1H, d, J = 12.5 Hz, C_9–Hb), 6.18 (1H, br s, C_2–H).

Ligularinine (5): Colorless prisms, mp 103—104 °C, $[\alpha]_D^{24}$ −88° (c = 0.82, $CHCl_3$). High resolution MS: Calcd for $C_{18}H_{27}NO_5$: 337.189. Found: 337.187. MS *m/z* (%): 337 (M^+, 9), 266 (5), 211 (30), 140 (100), 138 (58), 123 (49), 122 (72), 96 (26), 95 (16), 82 (98). IR ν_{max}^{KBr} cm^{-1}: 3400, 1730, 1715. ^{1}H-NMR ($CDCl_3$) δ: 0.99 (3H, d, J = 6.5 Hz, C_{19}–H), 1.24 (3H, s, C_{18}–H), 1.87 (3H, d, J = 7.5 Hz, C_{21}–H), 3.43 (1H, dd, J = 7, 5 Hz, C_8–H), 4.08 (1H, dd, J = 12, 2 Hz, C_9–Ha), 4.57 (1H, dd, J = 12, 8 Hz, C_9–Hb), 5.22 (1H, q, J = 5 Hz, C_7–H), 5.81 (1H, q, J = 7.5 Hz, C_{20}–H).

Catalytic Reduction of Clivorine (1) to Ligularidine (2), Neoligularidine (3) and 6——**1** (1 g) was dissolved in EtOH (10 ml) containing AcOH (0.1 ml) and shaken with Pd-C (100 mg) under an atmosphere of hydrogen at room temperature. The catalyst was removed by filtration and the filtrate was then evaporated to dryness *in vacuo* to give a mixture of dihydro derivatives (1.01 g). The mixture was dissolved in $CHCl_3$ and the solution was washed with water. The $CHCl_3$ layer was evaporated to give the residue (874 mg), which was recrystallized from acetone to give **2**

(188 mg). The residue obtained from the mother liquor of **2** was extracted with hot *n*-hexane and the solvent was evaporated. The residue was recrystallized from *n*-hexane to give **6** (199 mg). The mother liquor of **6** was separated by HPLC on a Senshu pack N505 column (solvent, CH_3CN : $CHCl_3$: MeOH : $Et_2NH = 300:300:5:0.8$; flow rate, 6 ml/min) to afford **2** (36 mg), **3** (135 mg) and **6** (118 mg), respectively. **2** and **3** were identical with naturally occurring specimens on the basis of mixed fusion, $[\alpha]_D$ and other spectral data. **6**: Colorless prisms, mp 124—125 °C (*n*-hexane), $[\alpha]_D^{25}$ +135° ($c=1.04$, $CHCl_3$). *Anal.* Calcd for $C_{21}H_{29}NO_7$: C, 61.90; H, 7.17; N, 3.44. Found: C, 61.71; H, 7.17; N, 3.27. IR ν_{max}^{KBr} cm^{-1}: 1745, 1728, 1720, 1615. MS *m/z* (%): 407 (M^+, 7), 363 (8), 320 (22), 304 (56), 168 (18), 166 (12), 153 (63), 137 (53), 125 (34), 122 (23), 110 (53), 43 (100). ^{1}H-NMR ($CDCl_3$) δ: 1.03 (3H, t, $J=8$ Hz, C_{21}–H), 1.14 (3H, d, $J=7.5$ Hz, C_{19}–H), 1.47 (3H, s, C_{18}–H), 2.02, 2.08 (each 3H, s, N–CH_3, O–CO–CH_3), 2.22 (1H, br q, $J=8$ Hz, C_{20}–H), 4.23 (1H, br d, $J=11$ Hz, C_9–Ha), 4.97 (1H, d, $J=11$ Hz, C_9–Hb), 5.26 (1H, t, $J=2$ Hz, C_7–H), 5.21 (1H, dt, $J=12$, 2, 2 Hz, C_{14}–H), 6.05 (1H, br s, C_2–H).

Conversion of Neoligularidine (3) to Ligularizine (4)——**3** (40 mg) was dissolved in formic acid (0.5 ml). Thirty percent hydrogen peroxide (1.2 ml) was gently added to the above solution and the mixture was allowed to stand for 9 d at room temperature. The reaction mixture was diluted with water, made alkaline with 28% NH_4OH and extracted with $CHCl_3$ to afford a crude material (45 mg), which was converted to a crystalline picrate (39.7 mg). The residue obtained from the mother liquor of the picrate was chromatographed on Al_2O_3 with $CHCl_3$ to give the picrate (6.5 mg). The picrate of **4** was found to be identical with the picrate of naturally occurring ligularizine (**4**) on the basis of mixed fusion, $[\alpha]_D$ and other spectral data.

Hydrolysis of Ligularinine (5)——**5** (45 mg) in water (10 ml) was boiled under reflux with barium hydroxide octahydrate (234 mg) for 5 h. The solution was allowed to cool, treated with CO_2 gas, and filtrered, then the filtrate was acidified with HCl and extracted continuously with ether for 10 h. The ether extract was recrystallized from ether–*n*-hexane to give necic acid (**12**) (5 mg). The residual acidic solution was passed through a column of Amberlite IRA 400 ion-exchange resin (OH^- form, 5 g) and the eluate was evaporated to dryness. The residue was recrystallized from acetone to give platynecine (**11**) (10.2 mg). **12**: Colorless needles, mp 116—117 °C (ether–*n*-hexane), $[\alpha]_D^{26}$ +42.6° ($c=0.12$, EtOH). IR ν_{max}^{KBr} cm^{-1}: 3450, 1725, 1690, 1675. MS *m/z* (%): 198 ($M^+ - H_2O$, 12), 153 ($M^+ - H_2O$–COOH, 81), 127 (79), 109 (87), 81 (100). ^{1}H-NMR (CD_3COCD_3) δ: 0.81 (3H, d, $J=6$ Hz, C_8–H), 1.38 (3H, s, C_7–H), 1.95 (3H, d, $J=7$ Hz, C_{10}–H), 5.98 (1H, q, $J=7$ Hz, C_9–H). This necic acid (**12**) was identical with **12** obtained from neoligularidine (**3**) on the basis of mixed fusion, IR spectra and $[\alpha]_D$. **11**: Colorless prisms, mp 146—147 °C (acetone), $[\alpha]_D^{24}$ −63.4° ($c=0.15$, $CHCl_3$). *Anal.* Calcd for $C_8H_{15}NO_2$: C, 61.12; H, 9.62; N, 8.91. Found: C, 61.26; H, 9.61; N, 8.63. IR ν_{max}^{KBr} cm^{-1}: 3360, 1220, 1008, 735. MS *m/z* (%): 157 (M^+, 21), 113 (40), 82 (100). This base was identical with an authentic sample of platynecine on the basis of mixed fusion, IR spectra and $[\alpha]_D$.

Hydrolysis of Neoligularidine (3)——**3** (50 mg) in water (10 ml) was boiled under reflux with barium hydroxide octahydrate (184 mg) for 5 h. The solution was allowed to cool, treated with CO_2 gas, and filtered, then the filtrate was acidified with HCl and extracted continuously with ether for 10 h. The ether extract was recrystallized from ether–*n*-hexane to give necic acid (**12**) (7.3 mg) which was identical with **12** obtained from **5** on the basis of mixed fusion, IR spectra and $[\alpha]_D$.

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