18. Loganin, Loganic Acid and Periclymenoside, a New Biosidic Ester Iridoid Glucoside from *Lonicera periclymenum* L. *(Caprifoliaceae)*

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Summary

Loganin (**1**), loganic acid (**2**), and periclymenoside (**3**) have been isolated from *Lonicera periclymenum* L. The structure of the new compound **3** and the identity of the others have been determined by chemical transformations and interpretation of the spectral data.

Introduction. – The genus *Lonicera* consists of about 180 species of which five are native to Switzerland. In addition, four species and some hybrids are widely cultivated for ornamental purposes or have become locally naturalized [1]. Earlier investigations on this genus in the field of cyclopentanoid monoterpene glycosides resulted in the isolation and characterization of several iridoids, secoiridoids and three sulfur-containing monoterpene alkaloid glucosides. From the fresh fruits of *Lonicera morrowii* A. GRAY, the secoiridoid glucosides morroniside and kingiside [2], and from young leaves loniceroside (secologanin) and sweroside [3] have been isolated. *Bailleul et al.* [4] isolated alpigenoside, morroniside and kingiside from the fruits of *L. alpigena* L. Besides these secoiridoids the isolation of the iridoid glucoside loganin has also been reported for the *Lonicera* species [5]. Recently, *Chaudhuri et al.* isolated from *L. xylosteum* L. three novel sulfur-containing monoterpene alkaloid glucosides, xylostosidine [6] and loxylostosidine A and B [7].

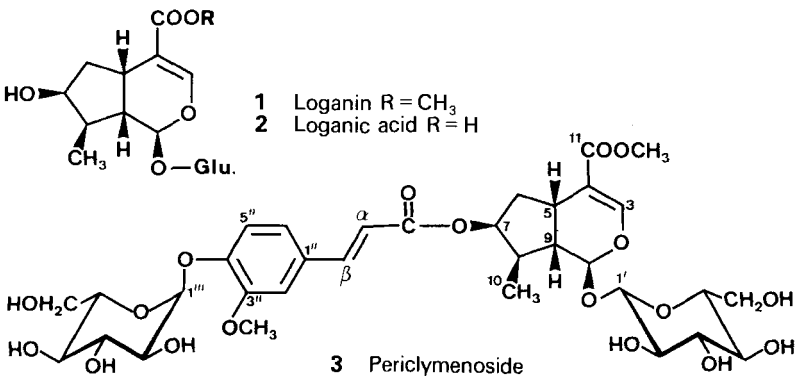

Table 1. *^{1}H-NMR (300.13 MHz) Spectral Data of Loganin* (**1**), *Loganic Acid* (**2**), *Periclymenoside* (**3**), *4-O-(β-D-Glucopyranosyl)-*trans*-ferulic Acid* (**4**) *and Periclymenoside Octaacetate* (**5**)[a])

Proton(s)	**1**	**2**	**3**[b])	**4**[c])	**5**[d])
H–C(1)	5.26 (*d*, *J* = 4.5)	5.26 (*d*, *J* = 4.4)	5.30–5.27		5.31–4.96
H–C(3)	7.38 (*d*, *J* = 1.2)	7.38 (*s*)	7.44 (*s*)		7.31 (*d*, *J* = 1.1)
H–C(5)	3.12 (*m*)	3.10 (*m*)	3.16 (*m*)		3.07 (*m*)
H_α–(6)	1.62 (*m*)	1.66 (*m*)	1.79 (*m*)		1.84 (*m*)
H_β–(6)	2.03 (*m*)	2.03 (*m*)	2.13 (*m*)		2.09–1.96
H–C(7)	4.04 (*m*)	4.04 (*m*)	5.30–5.27		5.31–4.96
H–C(8)	1.87 (*m*)	1.87 (*m*)	2.17 (*m*)		2.39–2.27
H–C(9)	2.23 (*m*)	2.23 (*m*)	2.34 (*dd*, *J* = 14.7, 8)		2.39–2.27
CH_3(10)	1.09 (*d*, *J* = 6.9)	1.09 (*d*, *J* = 6.8)	1.10 (*d*, *J* = 6.5)		1.07 (*d*, *J* = 6.7)
$COOCH_3$	3.69 (*s*)		3.70 (*s*)		3.70 (*s*)
H–C(1′)	4.64 (*d*, *J* = 7.8)	4.65 (*d*, *J* = 7.8)	4.68 (*d*, *J* = 7.9)		4.87 (*d*, *J* = 8.1)
H–C(2′)					
H–C(3′)	3.40–3.19	3.41–3.17	3.56–3.20		5.31–4.96
H–C(4′)					
H–C(5′)					3.87–3.70
2H–C(6′)	3.89 (*dd*, *J* = 12.0, 1.8) 3.66 (*dd*, *J* = 12.0, 5.7)	3.89 (*dd*, *J* = 11.0, 1.3) 3.67 (*dd*, *J* = 10.6, 5.4)	3.90[e])/3.70[e])		4.30 (*m*)/4.16 (*m*)
H–C(2″)			7.26 (br. *s*)	7.21 (*d*, *J* = 1.7)	
H–C(5″)			7.17 (br. *s*)	7.18 (*d*, *J* = 8.4)	7.13–7.04
H–C(6″)			7.17 (br. *s*)	7.13 (*dd*, *J* = 8.4, 1.7)	
H–C(α)			6.45 (*d*, *J* = 15.9)	6.40 (*d*, *J* = 16)	6.31 (*d*, *J* = 16)
H–C(β)			7.62 (*d*, *J* = 15.9)	7.53 (*d*, *J* = 16)	7.58 (*d*, *J* = 16)
$ArOCH_3$			3.90 (*s*)	3.91 (*s*)	3.87 (*s*)
H–C(1‴)			4.97 (*d*, *J* = 7.1)	4.96 (*d*, *J* = 7.5)	5.25 (*d*, *J* = 7.1)
H–C(2‴)					
H–C(3‴)			3.56–3.20	3.56–3.39	5.31–4.96
H–C(4‴)					
H–C(5‴)					3.87–3.70
2H–C(6‴)			3.90[e])/3.70[e])	3.90 (*dd*, *J* = 12.6, 1.8) 3.72 (*dd*, *J* = 12.6, 5.7)	4.30 (*m*)/4.16 (*m*)

[a]) The spectra were recorded in CD_3OD (**1**–**4**) and $CDCl_3$ (**5**). Chemical shifts in ppm relative to internal TMS. Values in parenthesis are coupling constants in Hz.

[b]) The protons at C(5), C(6), C(8), and C(9) have been assigned by selective irradiations at 1.100, 2.3069, and 3.1602 ppm.

[c]) For a better comparison, **4** is numbered like **3**.

[d]) Additional signals: 2.09, 2.08, 2.075, 2.04, 2.035, 2.03, 2.00, 1.92 (8 CH_3COO, aliph.).

[e]) Partly merged with the CH_3O signals.

As a part of the systematic isolation and structure determination of cyclopentanoid monoterpene glycosides from various plants belonging to the family *Caprifoliaceae*, we have studied the water-soluble constituents of *Lonicera periclymenum*, isolating two known iridoids (**1**, **2**) and a new iridoid ester glucoside (**3**). Spectral analyses of the latter led to a novel biosidic ester iridoid structure.

Results and Discussion. – An aqueous extract of the stems of *L. periclymenum* L. was fractionated by polyamide column chromatography followed by silica gel column chromatography and/or semipreparative scale separation using reversed phase HPLC. The chromatographic separation afforded 3 iridoid and 4 secoiridoid glucosides. This paper reports the isolation and structure determination of the iridoid constituents **1**–**3**. Two of them, loganin (**1**) and loganic acid (**2**) were well known and identified by means of physical constants, spectral data, and comparison with authentic samples. The structure elucidation of the remaining glucoside (**3**) is described here.

Periclymenoside (**3**), $C_{33}H_{44}O_{18}$, $[\alpha]_D^{20} = -54.2°$ (MeOH), was obtained as a white amorphous powder. It showed UV absorptions at 220, 234, 293, and 318 nm and IR bands for hydroxy groups, an ester carbonyl, an enolic double bond and an aromatic ring.

Acid hydrolysis of **3** in refluxing aqueous 3N HCl yielded D-glucose and (*E*)-3-(4-hydroxy-3-methoxyphenyl)-2-propenoic acid (ferulic acid). Glucose was detected by TLC and ferulic acid by HPLC (reversed phase, MeOH/H_2O/AcOH 30:70:0.5).The ^{1}H-NMR spectrum of **3** *(Table 1)* showed, beside loganin protons, protons for an acyl unit (ferulic acid) and one more glucose moiety.

The signals for the olefinic protons of the acyl unit were located at 7.62 (H–C(β)) and 6.45 ppm (H–C(α)) with $J = 15.9$ Hz. The three aromatic protons appeared as 2 broad *s* at 7.26 ppm (H–C(2″)) and 7.17 ppm (H–C(5″), H–C(6″)). This deceptively simple spectrum is, compared with the *ABX* spectrum of unsubstituted ferulic acid [8] [7.15 (*d*, H–C(2)); 7.04 (*dd*, H–C(6)); 6.80 (*d*, H–C(5))], due to the glycosylation at OH–C(4″) which causes downfield shifts of about 0.3 ppm at the *ortho* and 0.13 ppm at the *meta* position. The CH_3O-group of the acyl unit appeared at 3.90 ppm (CH_3OAr). These facts led us to the conclusion that periclymenoside (**3**) has a *trans*-feruloyl unit as the acyl function (*cf.* [8]).

The lack of chemical-shift differences for the protons of the two glucose molecules showed the *trans*-feruloyl residue to be esterified at the secondary alcoholic function of the aglycone (C(7)–OH). This result was corroborated by comparison of the chemical shifts of H–C(7) of loganin and periclymenoside (4.04 and 5.30–5.27 ppm, respectively).

The ^{13}C-NMR spectrum *(Table 2)* also showed periclymenoside to have an aromatic and a second glucose moiety in addition to the loganin C-atoms.

The ^{13}C-NMR spectrum of **3**, in comparison with the spectra of **1** and **2**, shows only few distinguishable differences in the chemical shifts of C(6), C(7), and C(8) *(Table 2)* of the loganin moiety. The position of the acyloxy unit (at C(7)) in **3** was based on the expected downfield shift ($\Delta\delta = +3.68$ and $+3.94$ ppm compared with loganic acid and loganin, resp.) for the signal of the C-atom in the α-position (C(7)) and the high field shifts ($\Delta\delta = -2.04$ and -2.24 ppm and -0.88 and -1.09 ppm, resp.) for the signals of the C-atoms in the β-position (C(6) and C(8)) (*cf.* [9]).

The chemical shifts of the C-atoms of the two glucose molecules of **3** were similar, with exception of those of the anomeric C-atoms (102.24 and 100.31 ppm). This indicated that periclymenoside has two glucose moieties as terminal sugars. This suggestion was corroborated by alkaline hydrolysis of **3** in refluxing aqueous 5% KOH, which afforded **2** and **4**. The ^{1}H-NMR spectrum of **4** *(Table 1)* exhibited protons for *trans*-ferulic acid and one molecule of glucose. This finding led us to decide that **4** has a

Table 2. *^{13}C-NMR (75.47 MHz) Spectral Data of Loganin* (**1**), *Loganic Acid* (**2**), *Periclymenoside* (**3**), *4-O-(β-D-Glucopyranosyl)-*trans*-ferulic Acid* (**4**) *and Periclymenoside Octaacetate* (**5**)[a])

C-Atom	1	2	3	4	5
C(1)	97.81	97.58	97.79		94.62
C(3)	152.22	152.04	152.80		148.97
C(4)	114.06	114.24	113.17		113.79
C(5)	32.24	32.70	32.81		29.83
C(6)	42.79	42.59	40.55		39.01
C(7)	74.77	75.03	78.71		77.23
C(8)	42.24	42.03	41.15		39.17
C(9)	46.55	46.42	47.19		45.63
C(10)	13.61	13.45	14.02		12.47
C(11)	169.60	171.40	169.47		166.99
$COOCH_3$	51.85		52.04		51.25
C(1′)	100.11	99.89	100.31		95.91
C(2′)	75.12	74.60	74.82		71.20
C(3′)	78.04	77.85	78.03		72.25
C(4′)	71.62	71.44	71.65		68.44
C(5′)	78.36	78.12	78.38		72.58
C(6′)	62.84	62.67	62.88		61.98
C(1″)			130.53	131.48	130.90
C(2″)			112.55	112.46	111.52
C(3″)			150.97[b])	150.67[b])	150.79
C(4″)			150.08[b])	149.17[b])	147.88
C(5″)			117.41	117.46	121.64
C(6″)			123.74	123.26	119.53
C(α)			117.60	121.37	117.57
C(β)			146.20	143.93	144.07
C=O			168.61	174.10	166.28
CH_3OAr			57.00	57.15	56.11
C(1‴)			102.24	102.17	100.32
C(2‴)			74.82	74.69	70.66
C(3‴)			77.82	77.46	72.19
C(4‴)			71.33	71.21	68.32
C(5‴)			78.27	78.03	72.47
C(6‴)			62.58	62.30	61.76
CO(Ac)					170.42–169.06
CH_3(Ac)					20.69–20.15

[a]) The spectra were recorded in CD_3OD (**1–4**) and $CDCl_3$ (**5**). Chemical shifts in ppm relative to internal TMS. For a better comparison, **4** is numbered like **3**.

[b]) Values are interchangeable.

4-*O*-(β-D-glucopyranosyl)-*trans*-ferulic acid structure. The glycosylation at C(4″) is also verified through ^{13}C-NMR chemical shift differences of **3** and **4** compared with model compounds like flavonoids [10] and ester iridoids like verbellidoside [8].

It is well known that glycosylation produces an upfield shift in the signal of oxygenated phenolic C-atoms and downfield shifts of the signals of the *ortho*- and *para*-related C-atoms, the effect being more noticeable for the signal of the *para*-related C-atom [10]. In the ^{13}C-NMR spectra of **3** and **4** *(Table 2)* a downfield shift (3–4 ppm) for the signal of C(1″) in comparison with verbellidoside [8] can be attributed to the *para*-effect of glycosylation at OH–C(4″) (130.53 ppm (**3**), 131.48 ppm (**4**), 127.52 ppm (verbellidoside [8])).

The configuration of the two terminal glucose linkages of **3** was deduced to be the β-D-form from the ^{1}H-NMR spectrum (J = 7.1 Hz and 7.9 Hz). Acetylation of **3** under mild conditions provided the fully acetylated derivative **5**.

The ^{1}H-NMR spectrum of **5** revealed the presence of eight acetyl signals belonging to eight aliphatic acetyl groups of two terminal glucose molecules (*s* at 2.09, 2.08, 2.075, 2.04, 2.035, 2.03, 2.00, and 1.92 ppm). In the electron impact mass spectrum (MS(EI)) of periclymenoside octaacetate (**5**), a molecular ion peak was not visible. However, MS data established the sequence to be glucose-*trans*-ferulic acid-aglycone-glucose: *m/z* 734 (M^+ – tetra-*O*-acetylglucose oxonium ion), 331 (tetra-*O*-acetylglucose oxonium ion), and 404 ($M^+ - 2 \times$ tetra-*O*-acetylglucose oxonium ion). On the other hand, periclymenoside (**3**) was found to possess the composition $C_{33}H_{44}O_{18}$ (M^+ = 728, MS(FD)). The field desorption mass spectrum (MS(FD)) of periclymenoside showed the $[M + Na]^+$ ion at *m/z* 751. Other fragment peaks recorded in the MS(FD) spectrum were $[(M + Na) - 162(\text{glucosyl})]^+$ at *m/z* 589, $[M + 2\ Na]^{++}$ at *m/z* 387, $[M - 162(\text{glucosyl})]^+$ at *m/z* 566, and *m/z* 163 (glucosyl).

Based on these data, periclymenoside was identified as 7-*O*-[4″-*O*-(β-D-glucopyranosyl)-*trans*-feruloyl]]loganin (= 7-*O*-[(*E*)-β-(4″-(β-D-glucopyranosyloxy)-3″-methoxyphenyl)propenoyl]]loganin **3**).

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Experimental Part

General. Melting points were determined on a *Mettler FP5/FP52* apparatus. UV spectra [$\lambda_{max}(\log \varepsilon)$] were determined in spectroscopic grade MeOH *(Merck)* on a *Perkin-Elmer 550* and a *Zeiss PMQ 3* spectrophotometer. IR spectra (cm^{-1}) were determined on a *Perkin-Elmer 257* instrument in KBr pellets. Optical rotations were measured with a *Perkin-Elmer 141* polarimeter. ^{1}H- and ^{13}C-NMR spectra (δ ppm, *J* Hz) were obtained at 300.13 MHz (^{1}H-NMR) and at 75.47 MHz (^{13}C-NMR) using a *Bruker WM 300 Spectrospin* instrument in *Fourier* transform mode, MS(EI) *(m/z)* were recorded with a *Hitachi-Perkin-Elmer RMU 6M* spectrometer and MS(FD) with a *Varian MAT 731* and *Varian Spektro-System 200*. Polyamide *(Woelm)* and silica gel *60* (70–230 mesh, *Merck*) were used for column chromatography and silica gel *60* F_{254} *(Merck)* and cellulose F_{254} *(Merck)* prepared plates for TLC. Spots were detected by UV fluorescence and/or spraying with vanillin/H_2SO_4 or aniline phthalate reagent (for sugars) followed by heating at 100° for 5–10 min. A *Waters Assoc.* HPLC instrument, model *ALC 201* was used throughout, together with a *Waters Assoc. M 6000* pump for the anal. work or a *Kontron LC 410* pump for semiprep. work as the solvent delivery system and a *U6K* septumless injector. The system was equipped with a *Perkin-Elmer* spectrophotometer *(LC 85)* with a variable wave length detector. The separation was monitored by a *Spectra Physics SP 4000* chromatography data system. For the anal. and semiprep. HPLC work, *Lichrosorb RP 18* prepacked columns *(Knauer)* were used (25 cm × 4 mm i.d. and 25 cm × 16 mm i.d., respectively).

Extraction and Purification. Fresh plant material of *Lonicera periclymenum* was collected from the Forch area, Zurich, Switzerland, in August 1982. The stems of the plant (330 g) were cut into small pieces and extracted with MeOH at 40° (2 × 3 l). After concentration of the combined extracts *in vacuo*, H_2O (0.5 l) was added, and the H_2O-insoluble material was removed by filtration. The filtrate was exhaustively extracted with petroleum ether, and the soluble part was rejected. The aq. concentrate was lyophilized to give the crude extract (35 g). This crude extract was chromatographed over polyamide (150 g) with H_2O, MeOH/H_2O 5–50%, and seven *fractions A-G* were collected.

Isolation of Loganin (**1**) *and Loganic Acid* (**2**). *Fraction A* (15.4 g) was rechromatographed over silica gel (300 g) with CH_2Cl_2/MeOH/H_2O 80:20:2, 70:30:3, and 60:40:4 and seven *fractions* A_1–A_7 were collected.

Isolation of Loganin (**1**). *Fr.* A_4 (200 mg), which was subjected to semiprep. HPLC (MeOH/H_2O 3:7; flow rate 10 ml/min), gave pure **1**, $[\alpha]_D^{20} = -74.3°$ (c = 0.83, MeOH). UV (MeOH): 235 (4.01). ^{1}H-NMR and ^{13}C-NMR: *Tables 1* and *2*.

Isolation of Loganic Acid (**2**). *Fr. A_6* (200 mg), which was subjected to semiprep. HPLC ($MeOH/H_2O$ 5:95; flow rate 10 ml/min), gave pure **2**, $[\alpha]_D^{20} = -84.5°$ ($c = 0.91$, MeOH). UV (MeOH): 232 (3.94). ^{1}H-NMR and ^{13}C-NMR: *Tables 1* and *2*.

Isolation of Periclymenoside (*= 7-O-[(E)-β-(4"-(β-D-Glucopyranosyloxy)-3"-methoxyphenyl)propenoyl]-loganin;* **3**). *Fr. C* (530 mg) was chromatographed over silica gel (60 g), eluting with $CH_2Cl_2/MeOH/H_2O$ 80:20:2, to give **3** (110 mg), $[\alpha]_D^{20} = -54.2°$ ($c = 0.71$, MeOH). UV (MeOH): 220 (4.15), 234 (4.22), 293 (4.08), 318 (4.08). IR (KBr) 3420 (br., OH), 1700 (conj. ester), 1630–1635 (C=C), 1510 (arom. ring). ^{1}H-NMR and ^{13}C-NMR: *Tables 1* and *2*. MS(FD): 751 $[M + Na]^+$, 589 $[(M + Na) - 162]^+$, 566 $[M - 162]^+$, 387 $[M + 2\,Na]^{++}$. MS(EI). (70 eV): 728 (M^+, no peak), 566 (1.5), 404 (13.4), 373 (1.2), 355 (0.6), 339 (0.7), 338 (0.7), 229 (2.1), 228 (5.5), 211 (17.5), 210 (41.1), 195 (37.3), 194 (96.0), 193 (60.4), 192 (39.0), 191 (7.3), 182 (31.5), 181 (24.8), 177 (99.8), 167 (4.0), 164 (6.7), 163 (6.0), 160 (19.5), 161 (17.8), 151 (17.8), 150 (73.3), 149 (44.4), 145 (39.1), 144 (10.6), 139 (34.4), 135 (21.0), 133 (19.4), 127 (17.6), 123 (9.6), 121 (11.7), 119 (14.2), 117 (14.1), 109 (20.9), 108 (21.5), 107 (13.4), 105 (19.1), 103 (21.2), 99 (13.2), 98 (16.9), 97 (33.2), 96 (11.2), 93 (11.2), 91 (35.6), 89 (19.8), 87 (44.4), 86 (8.7), 85 (70.0), 84 (8.2), 83 (14.2), 81 (27.0), 80 (29.2), 79 (17.3), 77 (22.7), 73 (97.9), 60 (94.7), 57 (100.0), 56 (30.8), 55 (42.9), 53 (16.0), 47 (11.8). Peaks with an intensity below 10% are only listed if they are of significance for fragmentation pattern.

Acid Hydrolysis of Periclymenoside (**3**). Acid hydrolysis of **3** (5 mg) in 2 ml of refluxing aq. 3N HCl for 3 h yielded D-glucose and *(E)*-3-(4-hydroxy-3-methoxyphenyl)propenoic acid. The sugar was detected by TLC (cellulose F_{254} *(Merck)*, EtOAc/pyridine/AcOH/H_2O 36:36:7:21) and the acid by HPLC (reversed phase, MeOH/H_2O/AcOH 30:70:0.5).

Alkaline Hydrolysis of Periclymenoside (**3**). Alkaline hydrolysis of **3** (50 mg) in 10 ml of refluxing aq. 5% KOH for 2 h gave loganic acid (**2**) and (E)-*3-(4-(β-D-glucopyranosyloxy)-3-methoxyphenyl)propenoic acid* (**4**).

*Isolation of 4-O-β-D-glucopyranosyl-*trans*-ferulic Acid* (**4**). After neutralization of the alkali hydrolysate with aq. 1N HCl, the solution was evaporated to dryness and the residue dissolved in MeOH. The solution obtained was chromatographed over silica gel (40 g), eluting with $CHCl_3/MeOH/H_2O$ 61:32:7, to give **4** (17 mg) and **2** (20 mg). Acid **4**, $[\alpha]_D^{20} = -17.9°$ ($c = 0.58$, MeOH), was identified by interpretation of its ^{1}H-NMR and ^{13}C-NMR *(Tables 1* and *2)*. Loganic acid (**2**) was detected using anal. HPLC (reversed phase, $MeOH/H_2O$ 5:95) by comparison with an authentic sample.

Periclymenoside Octaacetate (*= 2',3',4',6'-Tetra-O-acetyl-7-O-[(E)-β-(4"-(2"',3"',4"',6"'-tetra-O-acetyl-β-D-glucopyranosyloxy)-3"-methoxyphenyl)propenoyl]loganin;* **5**). Acetylation of **3** (30 mg) with Ac_2O/pyridine at r.t. for 24 h followed by prep. TLC (silica gel, Et_2O/EtOAc 1:1) gave **5**, $[\alpha]_D^{20} = -50.3°$ ($c = 0.82$, $CHCl_3$). ^{1}H-NMR and ^{13}C-NMR: *Tables 1* and *2*. MS(EI) (70 eV), scan 2 (mass range 311–764): 1064 (M^+, no peak), 734 (6.8), 692 (1.8), 674 (0.3), 524 (1.1), 507 (1.2), 465 (7.8), 446 (3.2), 422 (1.9), 407 (9.5), 404 (2.3), 387 (4.4), 365 (1.9), 355 (1.4), 347 (1.9), 345 (0.6), 332 (35.7), *331* (100). Scan 1 (mass range 12–340): 332 (16.3), *331* (100.0), 289 (4.6), 271 (14.8), 247 (1.0), 245 (1.2), 229 (14.6), 215 (1.9), 211 (13.2), 194 (36.5), 193 (39.7), 187 (9.6), 177 (11.5), 169 (93.5), 163 (2.4), 161 (17.2), 160 (18.2), 159 (16.9), 157 (11.9), 150 (8.4), 149 (7.2), 145 (28.4), 139 (31.1), 135 (3.1), 133 (10.8), 127 (68.6), 123 (2.4), 109 (91.6), 107 (3.8), 105 (8.3), 103 (25.3), 97 (33.7), 91 (15.4), 85 (15.3), 81 (27.0), 79 (6.6), 77 (12.9), 60 (10.2), 43 (91.9). Peaks with an intensity below 5% are only listed if they are of significance for fragmentation pattern.

REFERENCES

[1] *H.E. Hess, E. Landolt & R. Hirzel,* Flora der Schweiz, Vol. *3,* Birkhäuser Verlag, Basel and Stuttgart, 1972, p. 315.

[2] *I. Souzu & H. Mitsuhashi,* Tetrahedron Lett. *1969,* 2725.

[3] *I. Souzu & H. Mitsuhashi,* Tetrahedron Lett. *1970,* 191.

[4] *F. Bailleul, A.M. Leveau & M. Durand,* J. Nat. Prod. *44,* 573 (1981).

[5] *V. Plouvier,* C.R. Hebd. Séances Acad. Sci. *258,* 3919 (1964).

[6] *R.K. Chaudhuri, O. Sticher & T. Winkler,* Helv. Chim. Acta *63,* 1045 (1980).

[7] *R.K. Chaudhuri, O. Sticher and T. Winkler,* Tetrahedron Lett. *22,* 559 (1981).

[8] *M.F. Lahloub,* Thesis, ETH Zürich, No. 7340, 1983.

[9] *R.K. Chaudhuri, F.Ü. Afifi-Yazar, O. Sticher & T. Winkler,* Tetrahedron *36,* 2317 (1980).

[10] *K.R. Markham, B. Ternai, R. Stanley, H. Geiger & T.J. Mabry,* Tetrahedron *34,* 1389 (1978).