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NEW SESQUITERPENE POLYESTERS FROM *EUONYMUS* SPECIES

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ABSTRACT.—Five new sesquiterpene polyesters [**1**, **4**, **6**, **8**, **9**] based on the dihydro-β-agarofuran skeleton were isolated, together with twelve known compounds of the same type, from the fruits of *Euonymus nanus* and *E. sachalinensis*. The structures were elucidated by spectral methods and comparison with related compounds. Biological evaluation showed that 1β,6α,15-triacetoxy-2β,9α-dibenzoyloxydihydro-β-agarofuran [**3**] and evonine [**16**] demonstrated insecticidal effects against *Pieris brassicae*.

The bark and fruits of some *Euonymus* species have traditionally been used as natural insecticides. Many characteristic bioactive compounds, such as sesquiterpene esters and alkaloids with insect antifeedant and insecticidal activities, and euonydins and cardenolides with cytotoxic activity, have already been isolated from *Euonymus* species (1–4).

Although the use of *Euonymus nanus* M. Bieb. and *E. sachalinensis* (F. Schmidt) Maxim (Celastraceae) as natural insecticides has not been reported, a preliminary insecticidal screening showed that the lipophilic extract of the fruits of both species exhibited moderate toxicity against the L_4 larvae of *Pieris brassicae* L. and *Hyphantria cunea* Drury, and a marginal effect against *Oncopeltus fasciatus* Dallas. In an investigation of the active principles of the extracts, a comprehensive phytochemical analysis was performed.

Our earlier work on *E. sachalinensis* and *E. nanus* yielded eight new sesquiterpene polyesters based on the dihydro-β-agarofuran skeleton (5,6). Further investigations reported herein have led to isolation of the related compounds **2–4**, **6**, **10**, **11**, **14**, **16**, and **17** from *E. nanus* and **1–5**, **7–13**, and **15** from *E. sachalinensis*. Five sesquiterpene esters [**1**, **4**, **6**, **8**, **9**] are new natural products, and **9** has a new polyhydroxylated dihydro-β-agarofuran core.

The isolated compounds that were available in sufficient quantity were tested for insecticidal activity against *Pieris brassicae*. 1β,6α,15-Triacetoxy-2β,9α-dibenzoyloxydihydro-β-agarofuran [**3**] and evonine [**16**] displayed moderate toxicity, but **2**, **5**, **11**, and **13** were found to be inactive.

RESULTS AND DISCUSSION

Lipophilic extracts of the fresh fruits of the two species under study were fractionated by cc on polyamide, then on Si gel, and further purified by prep. tlc and hplc to afford **2–4**, **6**, **10**, **11**, **14**, **16**, and **17** from *E. nanus*, and **1–5**, **7–13**, and **15** from *E. sachalinensis*.

Compound **1** was revealed by its uv, ir, fabms, and ^{1}H-nmr data to contain three

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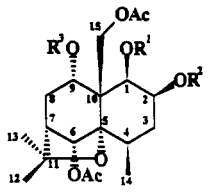
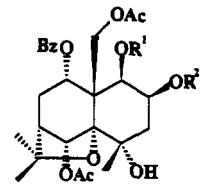
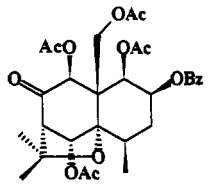


	R^1	R^2	R^3
1	H	Ac	Bz
2	Ac	Ac	Bz
3	Ac	Bz	Bz
4	Ac	Ac	Nic



	R^1	R^2
5	Ac	Bz
6	iBu	iBu
7	Ac	Ac



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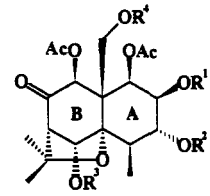

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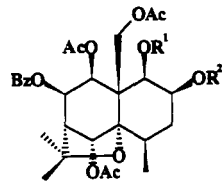
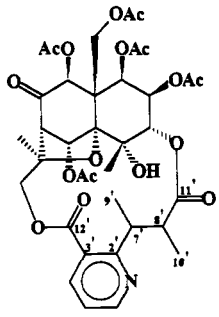
R^1-R^4 3×Ac; 1×Cin



	R^1	R^2
10	Bz	Bz
11	Bz	Ac
12	Bz	H
13	Ac	Ac
14	H	Ac
15	H	Bz



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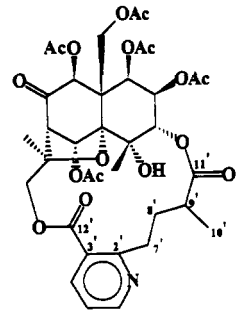

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Ac=acetyl, Bz=benzoyl, Cin=cinnamoyl, Nic=nicotinoyl, iBu=*iso*-butanoyl

acetates (δ_H 2.22 s, 2.10 s, 2.10 s), one benzoate [δ_H 8.07 d (ortho), 7.58 t (para), and 7.47 t (meta)], and one free hydroxy (δ_H 1.91 d) group. The ^{1}H-nmr chemical shifts, and multiplicity and coupling constants of **1** (Table 1) exhibited a close similarity to those

TABLE 1. ^{1}H-Nmr Spectral Data of Compounds **1**, **2**, **4**–**6**, **8**, and **9** [400 MHz, $CDCl_3$, δ ppm (*J* Hz), TMS as internal standard].

Proton	Compound						
	1[a]	**2**	**4**[b]	**5**	**6**[c]	**8**	**9**[d]
1	4.72 dd (4.9, 3.6)	5.71 d (3.2)	5.70 d (3.5)	5.71 d (3.5)	5.67 d (3.5)	5.71 d (3.5)	5.98 d (3.4)
2	5.33 dd (3.6, 7.3)	5.58 dd (3.2, 6.2)	5.53 dd (3.5, 6.8)	5.80 dd (3.5, 6.7)	5.56 dd (3.5, 6.7)	5.70 dd (3.5, 6.8)	5.49 ddd (3.4, 2.5, 1.1)
3	2.35 ddd (14.0, 7.3, 3.0)	2.53 m	2.35 ddd (14.3, 6.8, 3.0)	2.28 m[e]	1.8–2.4 m	2.41 m	4.92 dd (2.5, 1.1)
	1.83 dd (14.0, 3.0)	1.80 dd (15.0, 2.4)	1.80 dd (14.3, 3.0)	2.19 m[e]	1.98 dd (15.3, 3.1)	2.00 m	—
4	2.2–2.4 m	2.39 m	1.9–2.6 m	—	—	2.49 m	2.69 br q (7.9)
OH-4	—	—	—	2.93 s	2.89 s	—	—
6	5.85 s	5.97 s	5.96 s	6.17 s	6.16 s	6.42 s	6.37 d (0.9)
7	2.2–2.4 m	2.0–2.6 m	1.9–2.6 m	2.23 m[e]	1.8–2.4 m	3.07 s	3.03 d (0.9)
8	2.53 ddd (15.5, 7.3, 3.0)	2.56 ddd (14.9, 7.2, 2.5)	2.48 ddd (16.0, 7.0, 3.0)	2.62 ddd (15.7, 7.2, 3.4)	2.55 m	—	—
	2.28 dd (15.5, 3.0)	2.22 dd (14.9, 2.5)	2.21 dd (16.0, 3.0)	2.27 m[e]	1.8–2.4 m	—	—
9	5.48 d (7.3)	5.41 d (7.2)	5.43 d (7.0)	5.51 d (7.2)	5.35 d (6.7)	5.62 s	5.65 s
12,13	1.50 s, 1.43 s	1.45 s, 1.42 s	1.42 s, 1.42 s	1.59 s, 1.55 s	1.55 s[f], 1.50 s[f]	1.45 s, 1.52 s	1.45 s, 1.45 s
14	1.16 d (7.6)	1.19 d (7.6)	1.19 d (7.6)	1.56 s	1.49 s[f]	1.29 d (8.4)	1.29 d (7.9)
15	4.87 d (12.6)	5.05 d (12.7)	5.04 d (13.0)	5.29 d (12.7)	5.03 d (13.1)	4.90 d (12.8)	4.83 d (12.8)
	4.45 d (12.6)	4.36 d (12.7)	4.36 d (13.0)	4.48 d (12.7)	4.41 d (13.1)	4.81 d (12.8)	4.69 d (12.8)
Bz-2′,6′	8.07 d (7.9)	8.04 d (7.3)	—	8.11 d (7.3), 8.05 d (7.3)	8.03 d (7.4)	8.05 d (7.5)	—
Bz-4′	7.58 t (7.4)	7.57 t (7.4)	—	7.59 t (7.1) (2H)	7.56 t (7.5)	7.50 t (7.6)	—
Bz-3′,5′	7.47 t (7.8)	7.44 t (7.6)	—	7.50 t (7.8) 7.47 t (7.6)	7.45 t (7.7)	7.60 m	—
Acetyls	2.22 s	2.25 s	2.25 s	2.29 s (C-15)	2.27 s	2.14 s	2.14 s
	2.10 s	2.11 s	2.11 s	2.12 s (C-6)	2.11 s	2.09 s	2.14 s
	2.10 s	2.08 s	2.08 s	1.43 s (C-1)		2.06 s	2.11 s
		1.55 s	1.59 s			1.93 s	2.06 s
							1.97 s

[a]1-OH: δ_H 1.91 d (4.9).
[b]Nic: δ_H 9.24 d (1.7) (H-2′), 8.28 dt (8.0, 1.7) (H-4′), 7.40 dd (8.0, 4.8) (H-5′), 8.79 dd (4.8, 1.7) (H-6′).
[c]2×*i*-Bu: δ_H 0.58 d (7.0), 0.78 d (7.0), 0.87 d (7.0), 0.90 d (7.0), 4×CH_3; 2.06 m, 2.56 m, 2×-CH=.
[d]*t*-Cin: δ_H 7.60 m (2H), 7.42 m (3H) ArH; 7.76, 6.41 AXq (16.0) -CH=CH-.
[e]From ^{1}H-^{1}H COSY spectrum without the identification of multiplicity.
[f]Assignments may be interchanged.

data of the known **2**, proving the presence of the 1β,2β,6α,9α,15-pentasubstituted-dihydro-β-agarofuran parent skeleton (7). As is characteristic of this class of compounds, the signal of H-6 appears as a singlet because the dihedral angle between H-6_{ax} and H-7_{eq} is near to 90° (2, 3, 5–8). The double doublet signal at δ_H 4.72 (H-1), which coupled with H-2 (3.6 Hz) and with the free hydroxy group (4.9 Hz), suggested that the hydroxy group was situated on C-1. Acetylation of **1** with Ac_2O in pyridine afforded a product which, on the basis of its ^{1}H-nmr spectrum and tlc, was identical with **2**. Thus, the structure of **1** was elucidated as 1β-hydroxy-2β,6α,15-triacetoxy-9α-benzoyloxydihydro-β-agarofuran.

Compound **4** displayed bands characteristic of the pyridine ring at 222 and 263 nm. Its eims exhibited fragment peaks due to the sequential loss of HOAc, nicotinic acid, and a ketene unit (see Experimental). Analysis of the ^{1}H-nmr data of **4** confirmed the presence of four acetates (δ_H 2.25 s, 2.11 s, 2.08 s, and 1.59 s) and one nicotinoate [δ_H 9.24 d (H-2′), 8.28 dt (H-4′), 7.40 dd (H-5′), and 8.79 dd (H-6′)] group, and the same sesquiterpene core as in **1–3** (Table 1). The almost identical δ values for **2** and **4**, in the range 4.4–6.1, suggested the same distribution of aromatic and aliphatic ester groups. Additionally, the upfield singlet at δ_H 1.59 for an acetate methyl group indicated C-9 nicotinoyl and C-1 acetyl substitution (8). On the above basis, the structure of **4** was determined as 1β,2β,6α,15-tetraacetoxy-9α-nicotinoyloxydihydro-β-agarofuran.

Compound **5** was shown by study of its uv, ir, ^{1}H-nmr, and ^{13}C-nmr spectra to be a derivative of 1β,2β,4α,6α,9α,15-hexahydroxydihydro-β-agarofuran (=3-desoxymaytol) esterified with two benzoic acid [δ_H 8.11 d, 8.05 d (ortho), 7.59 t (para), 7.50 t, and 7.47 t (meta)] and three acetic acid moieties (δ_H 2.29 s, 2.12 s, 1.43 s). The ^{1}H-nmr spectrum of **5** was very similar to that of acetylpringlein, previously isolated from *Celastrus pringlei*, except for two proton signals [acetylpringlein: H-2 δ_H 5.48 br q (4 Hz) and H-9 δ_H 5.73 br d (7 Hz)] (9). The assignments of the ^{1}H-nmr signals of **5** were confirmed by means of ^{1}H-^{1}H COSY measurements. The relative configuration was elucidated via a NOESY experiment, as shown in Figure 1. The positions of the ester groups were established unambiguously using COLOC spectroscopy. The long-range correlations of the carbonyl carbon signals at δ_C 165.7 and 165.3 with the proton signals at δ_H 5.80 dd (H-2), 5.51 d (H-9), 8.11, and 8.05 (ortho-benzoyl) indicated the presence of benzoyl groups on C-2 and C-9. Similarly, the carbonyl carbon signals at δ_C 169.3, 170.3, and 170.6 correlated with the signals of H-1, H-6, and H-15, and with the acetyl methyl signals at δ_H 1.43, 2.12, and 2.29, respectively. The structure of **5** was therefore found to be identical to that of acetylpringlein, for which incorrect ^{1}H-nmr data were earlier published (9).

The ^{1}H-nmr and mass spectral data for **6** suggested the presence of one benzoate [δ_H 8.03 d (ortho), 7.56 t (para) and 7.45 t (meta)], two acetate (δ_H 2.27 s and 2.11 s), and two isobutyrate (δ_H 0.58 d, 0.78 d, 0.87 d, 0.90 d, 4×Me, 2.06 m, 2.56 m, 2×−CH=) ester groups, and the 3-desoxymaytol parent skeleton. The ^{1}H-nmr chemical shifts of one

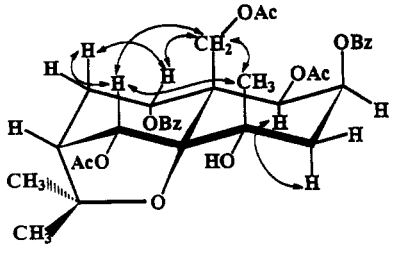

FIGURE 1. NOESY correlations of **6**.

isobutanoate group (δ_H 0.58 d, 0.78 d, 2×Me; 2.06 m, −CH=) were observed at higher field than usual. Accordingly, the isobutanoyl group was situated on C-1 and the aromatic ester on C-9 (2). The position of the other isobutanoyl group could be concluded from the mass spectrum. The presence of the peak at *m/z* 558, produced by the loss of one isobutanoic acid, and the absence of the fragment ion due to the loss of HOAc, indicated that the second isobutanoyl group was at C-2, for which a McLafferty rearrangement of the ester group is most favorable (2,10). Moreover, the two doublet peaks (δ_H 0.87 d, 0.90 d) in the ^{1}H-nmr spectrum confirmed a 2β-isobutanoyl substitution, because the two methyls of the isobutanoate at C-2β cannot rotate freely due to spatial hindrance (11). Based on the above data, the structure of **6** was elucidated as 1β,2β-diisobutanoyloxy-6α,15-diacetoxy-9α-benzoyloxy-4α-hydroxydihydro-β-agarofuran.

On the basis of its ^{1}H-nmr, ^{13}C-nmr, and mass spectral measurements, **8** was found to be an analogue of euosachalidin A, isolated earlier from *E. sachalinensis* (12). ^{1}H-Nmr chemical shifts, coupling constants, and NOESY correlations (Figure 2) indicated an identical polyhydroxydihydro-β-agarofuran core, and the esterifying acids were also the same: one benzoic [δ_H 8.05 d (ortho), 7.50 t (para), 7.60 m (meta)] and four acetic (δ_H 2.14 s, 2.09 s, 2.06 s, 1.93 s) acid moieties. The ^{1}H-nmr spectrum of **8** exhibited upfield-shifted H-1 (δ_H 5.71 d) and downfield-shifted H-2 (δ_H 5.70 dd) signals as compared with those of euosachalidin A [δ_H 5.89 d (H-1), 5.49 dd (H-2)], indicating a reversed, C-2 aromatic and C-1 aliphatic esterification. Accordingly, a high-field acetyl methyl signal, which is characteristic of C-1 aromatic, C-9 acetic substitution in this class of compounds, was missing. In the NOESY spectrum of **8**, cross-peaks were observed between the ortho-benzoyl protons, H-14 and H-15a, which also confirmed the position of the aromatic ester group at C-2. These spectroscopic observations showed the structure of **8** to be 1β,6α,9β,15-tetraacetoxy-2β-benzoyloxy-8-oxodihydro-β-agarofuran.

Compound **9** was obtained as an amorphous solid in a very small quantity. Its fabms spectrum displayed peaks at *m/z* 673 $[M+H]^+$ and 695 $[M+Na]^+$, suggesting a mol wt of 672. The ^{1}H-nmr spectrum revealed the presence of five acetyl (δ_H 2.14 s, 2.14 s, 2.11 s, 2.06 s, 1.97 s) group and one *trans*-cinnamoyl (δ_H 7.60 m, 7.42 m, 7.76, 6.41 AXq) group in the molecule. By considering these acyl substituents, a hexahydroxydihydro-β-agarofuran polyol bearing an oxo group could be deduced. The coupling constants of H-1–H-4 (1-H_{ax}–2-H_{eq} J=3.4 Hz; 2-H_{eq}–3-H_{eq} J=2.5 Hz; 3-H_{eq}–4-H_{eq} J=1.1 Hz) suggested an 1β,2β,3α,4β-substituted A-ring (13). The doublet signal at δ_H 6.37, which coupled with the proton signal at δ_H 3.03 (H-7), indicated an axial H-6. The singlet signal of H-9 (δ_H 5.65 s), and the paramagnetically shifted H-7 demonstrated that the oxo group must be sited at C-8. The stereochemistry of H-9 was proved by means of nOe experiments. On irradiation of the signal at δ_H 5.65, increases occurred in the intensities of the H-1 (21.6%) and H-13 (12.6%) signals, indicating the axial orienta-

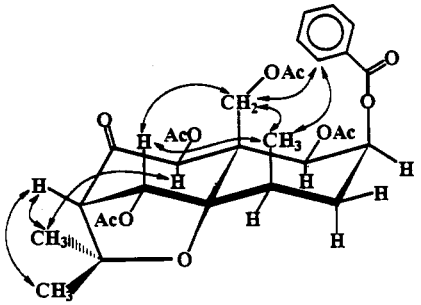

FIGURE 2. NOESY correlations of **8**.

TABLE 2. ^{13}C-Nmr Spectral Data of Compounds **3**, **5**, **8**, **13**, and **15–17** (100 MHz, $CDCl_3$, δ ppm, TMS as internal standard).

Carbon	Compound						
	3	**5**	**8**	**13**	**15**	**16**[a]	**17**[b]
1	69.5[c]	76.2	75.4	69.9[c]	71.4[c]	71.7	72.0
2	70.3[c]	70.5	70.2	71.9[c]	73.5[c]	68.5	69.1
3	31.0	42.2	31.1	32.3[d]	31.6[d]	74.9	75.2
4	33.1	69.6	33.2	33.8[d]	33.1[d]	70.7	70.0
5	89.3	91.3	91.6	91.2	90.0	95.4	95.1
6	71.5[c]	69.1	74.6	72.6[c]	73.8[c]	73.6	73.5
7	48.9	49.3	65.1	54.7	53.4	61.8	62.5
8	35.0	34.8	198.3	75.9[c]	74.8[c]	196.1	196.1
9	78.2[c]	78.2	79.1	78.3	77.5	78.4	78.6
10	53.3	55.1	51.1	51.8	50.5	52.4	52.4
11	82.8	84.7	83.2	81.9	81.4	85.8	86.1
12	30.3	29.4	30.4	31.3[d]	30.5[d]	70.0	70.3
13	26.0	25.8	25.0	25.7	24.5	19.6	18.8[c]
14	18.1	25.4	17.9	17.4	18.1	23.9	23.5
15	66.0	66.1	61.0	61.7	63.8	60.3	60.3
Benzoyl-CO	166.0	165.7	165.9	167.3	166.1		
	165.4	165.3			165.0		
Benzoyl-1′	129.8	129.6	130.5	131.2	129.0		
	129.3	129.1			129.0		
Benzoyl-2′,6′	130.2	130.2	129.7	131.0	130.0		
	129.9	129.9			129.6		
Benzoyl-3′,5′	128.7	128.7	128.8	129.4	128.6		
	128.4	128.4			128.5		
Benzoyl-4′	133.5	133.6	133.4	134.2	133.3		
	133.2	133.4			133.3		
Acetyl-CO	170.7	170.6	170.0	171.7	171.1	169.6	169.6
	169.9	170.3	169.4	170.8	169.7	169.2	169.3
	169.3	169.3	169.3	170.6	169.7	169.2	169.3
			169.0	170.4	169.6	169.1	169.2
				170.1		168.5	168.5
Acetyl-Me	21.3	21.5	21.1	22.2	21.2	21.4	21.4
	21.2	21.2	20.6	22.2	20.9	21.0	21.0
	20.4	20.3	20.6	22.2	20.9	20.5	20.5
			20.3	21.5	20.8	20.4	20.5
				21.5		20.1	20.2

[a]Evoninoyl: δ_C 165.6 (C-2′), 124.5 (C-3′), 137.8 (C-4′), 121.2 (C-5′), 151.7 (C-6′), 36.3 (C-7′), 44.9 (C-8′), 9.9 (C-10′), 11.9 (C-9′), 173.9 (C-11′), 168.4 (C-12′).

[b]Wilfordinoyl: δ_C 164.2 (C-2′), 124.2 (C-3′), 138.6 (C-4′), 121.2 (C-5′), 153.3 (C-6′), 33.2 (C-7′), 38.5 (C-8′), 18.5[c] (C-9′), 33.4 (C-10′), 174.9 (C-11′), 166.9 (C-12′).

[c,d]Chemical shift values in any vertical column may be interchanged.

tion of H-9. From these results, the structure of the polyol core was elucidated as 1β,2β,3α,6α,9β,15-hexahydroxy-8-oxodihydro-β-agarofuran (= 4,12-didesoxy-evoninol), which is a new sesquiterpene alcohol. The positions of the ester groups could not be determined, since there are no analogous compounds and further spectroscopic investigation was not carried out because of the small available quantity of the isolate. From the absence of a diamagnetic shifted acetyl methyl signal, 1,9-diacetyl substitution was concluded.

Eleven known dihydro-β-agarofurans [**2**, **3**, **7**, **10–17**] were also isolated from the fruits of *E. nanus* and *E. sachalinensis*, and identified on the basis of their ^{1}H-nmr and mass spectral data. All compounds were previously reported as metabolites of *Euonymus* spp.

(7, 14–16). The ^{13}C-nmr data of **13** and **15–17**, which have not been reported earlier, are listed in Table 2.

EXPERIMENTAL

GENERAL EXPERIMENTAL PROCEDURES.—Uv spectra in MeOH were obtained on a Specord uv-vis spectrometer. Ir spectra were run as KBr disks on a Specord 75 instrument. ^{1}H-Nmr, ^{13}C-nmr, ^{1}H-^{1}H COSY, NOESY, and COLOC spectra were recorded on a Bruker AM-400 spectrometer at 400.13 MHz (^{1}H nmr) and 100.62 MHz (^{13}C nmr), using $CDCl_3$ as solvent and TMS as internal standard. Mass spectral measurements were carried out on a VG ZAB-SEQ tandem mass spectrometer operating at 30 keV in a NOBA matrix and on a Finnigan MAT 8430 instrument operating at 70 eV ionizing energy. Hrms measurements were made using a Finnigan MAT 8430 mass spectrometer at R=10,000 by the peak matching technique, with PFK as the reference standard. Cc was performed on a polyamide (Macherey-Nagel 0.05–0.16 mm) column using MeOH-H_2O (2:3 and 3:2) as eluent and on a Si gel 60 (Reanal 0.063–0.2 mm) column with a gradient system of cyclohexane-EtOAc (9:1, 8:2, and 7:3) as eluent. For tlc, Si gel $60F_{254}$ (Merck) and alumina $60F_{254}$ neutral type E (Merck) plates and the following developing systems were used: $CHCl_3$-$(CH_3)_2CO$ (95:5), C_6H_6-EtOAc (4:1), *n*-hexane-THF-MeCN (20:5:1), and cyclohexane-EtOAc-EtOH (60:30:0.1). Hplc was carried out on μPorasil (3.9×300 mm) Waters Millipore and on an SI-100S (4×250 mm) BST column, with cyclohexane-EtOAc-EtOH (60:30:1) as eluent, with detection at 254 nm.

PLANT MATERIAL.—The fruits of *E. nanus* were collected in October 1986, from the Nursery-Garden of the Town Planning Council, Debrecen, Hungary. The fruits of *E. sachalinensis* were gathered in September 1989, in the Nursery-Garden of Parks and Gardens, Tahi, Budapest, Hungary. The voucher specimens have been deposited at the Herbarium of the Museum of Natural Sciences in Budapest, Hungary.

EXTRACTION AND ISOLATION.—The fruits of *E. nanus* (900 g) were extracted with MeOH. The extract was concentrated, diluted with H_2O, and extracted with petroleum ether. The petroleum ether layer was chromatographed on a polyamide column. The sesquiterpene-containing fractions were rechromatographed on a Si gel column and further purified by tlc and hplc to yield compounds **2** (1 mg), **3** (3 mg), **4** (1 mg), **6** (3, mg), **10**, (4 mg), **11** (9 mg), **14** (4 mg), **16** (25 mg), and **17** (5 mg).

Fresh fruits (4.8 kg) of *E. sachalinensis* were extracted with MeOH at room temperature. The crude extract was concentrated *in vacuo* and partitioned between cyclohexane and H_2O. The organic phase was chromatographed on a polyamide column, then on a Si gel column. Further purification by prep. tlc and hplc yielded compounds **1** (2 mg), **2** (280 mg), **3** (12 mg), **4** (1 mg), **5** (20 mg), **7** (12 mg), **8** (19 mg), **9** (0.7 mg), **10** (2 mg), **11** (140 mg), **12** (163 mg), **13** (43 mg), and **15** (11 mg).

1β-Hydroxy-2β,6α,15-triacetoxy-9α-benzoyloxydihydro-β-agarofuran [**1**].—Amorphous solid: uv λ max (log ε) 233 (4.717), 268 sh (3.628), 277 (3.692), 281 (3.597) nm; ir ν max 3560, 2920, 1750, 1730, 1100, 710 cm^{-1}; hrms *m/z* 532.22755 (calcd for $C_{28}H_{36}O_{10}$, 532.23085) $[M]^+$; fabms *m/z* 555 $[M+Na]^+$ 533 $[M+H]^+$, 515 $[(M+H)-H_2O]^+$, 473 $[(M+H)-CH_3COOH]^+$ 411 $[(M+H)-PhCOOH]^+$; ^{1}H-nmr data, see Table 1.

1β,2β,6α,15-Tetraacetoxy-9α-nicotinoyloxydihydro-β-agarofuran [**4**].—Amorphous solid: uv λ max (log ε) 222 (4.158), 263 (3.538) nm; ir ν max 2920, 1740, 1720, 1270, 1240, 1090, 1030, 1020 cm^{-1}; hrms *m/z* 575.2414 (calcd for $C_{29}H_{37}NO_{11}$, 575.2366) $[M]^+$; eims *m/z* 575 $[M]^+$, 560 $[M-CH_3]^+$, 533 $[M-CH_2CO]^+$, 518 $[M-CH_3-CH_2CO]^+$, 500 $[M-CH_3-CH_3COOH]$, 440 $[M-CH_3-2\times CH_3COOH]$, 410 $[M-CH_2CO-C_5H_4NCOOH]$, 350 $[M-CH_2CO-C_5H_4NCOOH-CH_3COOH]$; ^{1}H-nmr data, see Table 1.

1β,6α,15-Triacetoxy-2β,9α-dibenzoyloxy-4α-hydroxydihydro-β-agarofuran [**5**].—Amorphous solid: uv λ max (log ε) 236 (4.543), 266 sh (3.489), 278 (3.576), 282 sh (3.665) nm; ir ν max 3560, 1740, 1730, 1600, 1250, 1100, 710 cm^{-1}; eims *m/z* 637 $[M-CH_3]^+$, 530 $[M-PhCOOH]^+$, 470 $[M-CH_3COOH-PhCOOH]^+$; ^{1}H-nmr data, see Table 1; ^{13}C-nmr data, see Table 2.

1β,2β-Diisobutanoyloxy-6α,15-diacetoxy-9α-benzoyloxy-4α-hydroxydihydro-β-agarofuran [**6**].—Amorphous solid: uv λ max (log ε) 235 (4.619), 268 sh (3.543), 278 (3.698), 282 sh (3.421) nm; hrms *m/z* 631.2756 (calcd for $C_{34}H_{46}O_{12}$, 631.2754) $[M-CH_3]^+$; eims *m/z* (rel. int. %) 646 $[M]^+$ (0.6), 631 $[M-CH_3]^+$ (4), 558 $[M-C_3H_7COOH]^+$ (2), 498 $[M-C_3H_7COOH-CH_3COOH]^+$ (31), 470 $[M-2\times C_3H_7COOH]^+$ (6); ^{1}H-nmr data, see Table 1.

1β,6α,9α,15-Tetraacetoxy-2β-benzoyloxy-8-oxodihydro-β-agarofuran [**8**].—Amorphous solid: uv λ max (log ε) 232 (3.977), 268 sh (2.871), 273 (2.901), 282 sh (2.803) nm; hrms *m/z* 588.22768 (calcd for $C_{30}H_{36}O_{12}$, 588.22069) $[M]^+$; fabms *m/z* 611 $[M+Na]^+$, 589 $[M+H]^+$, 547 $[(M+H)-CH_2CO]^+$, 529 $[(M+H)-CH_3COOH]^+$, 467 $[(M+H)-PhCOOH]^+$; ^{1}H-nmr data, see Table 1; ^{13}C-nmr data, see Table 2.

Compound **9**.—Amorphous solid: uv λ max (log ε) 219 (3.832), 226 (3.857), 283 (3.849) nm; hrms *m/z* 672.24245 (calcd for $C_{34}H_{40}O_{14}$, 672.24182); fabms *m/z* 695 $[M+Na]^+$, 673 $[M+H]^+$, 613 $[(M+H)-CH_3COOH]^+$, 525 $[(M+H)-PhCH=CHCOOH]^+$; ^{1}H-nmr data, see Table 1.

BIOASSAYS.—The samples were tested for larvicidal activity on freshly molted fourth instar (L_4) larvae of the large white cabbage butterfly, *Pieris brassicae* L. (Lepidoptera, Pieridae). Dosages of 50 to 200 μg/specimen were applied topically in 2-μl amounts of $(CH_3)_2CO$ solutions to the dorsal surface of thorax. Control animals received the solvent only. The caterpillars were kept in plastic cups at 25° and fed with fresh leaves of savoy. The mortality of larvae was established when control larvae had ecdysed to the fifth instar. At the highest dose applied, 1β,6α,15-triacetoxy-2β,9α-dibenzoyloxydihydro-β-agarofuran [**3**] and evonine [**16**] exhibited some noticeable toxic action. While **3** induced 40% mortality, in the case of **16** mortality as high as 74% could be observed.

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