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A NEW NARDOSINANE SESQUITERPENE FROM THE BRAZILIAN
ENDEMIC GORGONIAN *PHYLLOGORGIA DILATATA*

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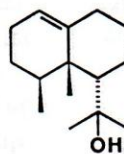
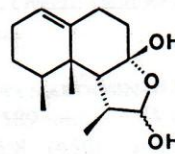
ABSTRACT.—The new nardosinane sesquiterpene, 11,12-epoxynardosin-1(10)-ene (**1**), has been isolated from the Brazilian endemic gorgonian *Phyllogorgia dilatata*, and its structure has been deduced from chemical and spectral data.

The occurrence of terpenes in coelenterates, and particularly in the Octocorallia, has been well documented (1). As part of our studies on Brazilian marine organisms, we have examined the endemic gorgonian, *Phyllogorgia dilatata* Esper (Octocorallia, Gorgonacea).

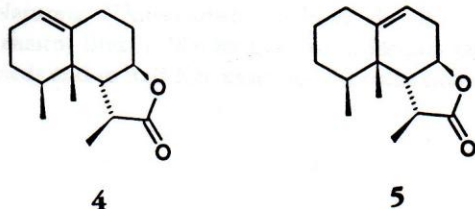
In a previous communication (2), we described the isolation and identification of steroids from the sea-fan *P. dilatata*. Further fractionation of the nonpolar material from the crude hexane extract allowed us to isolate **1** as a colorless odoriferous oil ($[\alpha]_D -62$). Ms indicated a molecular ion at m/z 220, corresponding to the general formula $C_{15}H_{24}O$, which was compatible with four degrees of unsaturation. The ^{13}C -nmr spectrum (see Experimental) not only confirmed the molecular formula, but also indicated the presence of three Me groups, six CH_2 groups, two CH groups, two quaternary carbons, and one trisubstituted double bond, and this established the tricyclic nature of **1**. The absence of either carbonyl or hydroxyl absorptions in the ir spectrum indicated that the oxygen atom of **1** was part of an

ether group. The AB system observed in the 1H -nmr spectrum at δ 2.57 and 2.75 (each d, $J = 6.5$ Hz), together with two carbon signals at δ 58.99 (s) and 59.87 (t), strongly suggested a terminal epoxide group, probably part of an isopropyl-oxide moiety (δ 1.39, 3H, s). This was corroborated in the ms by two intense fragment ions at m/z 190 (86) $[M - CH_2O]^+$ and 163 (83) $[M - C_3H_5O]^+$, and further confirmed by $LiAlH_4$ reduction of **1** in refluxing THF to afford the alcohol **2**: ir ν_{OH} 3400 cm^{-1} ; ms m/z $[M - H_2O]^+$ 204 (41), $[COH(Me)_2]^+$ 59 (100). The 1H -nmr spectrum of **2** lacked the AB signals of **1** and instead exhibited two 3-proton singlets at δ 1.32 and 1.36 in $CDCl_3$, or at δ 1.18 and 1.36 in C_6D_6 .

Further relevant signals in the 1H -nmr spectra of **1** and **2** were one olefinic H at δ 5.45 (m, $W_{1/2} = 11$ Hz) [**2**: δ 5.42 (m)] and two additional methyl groups, one quaternary at δ 1.04 (s) [**2**: δ 1.07 (s)], the other secondary at δ 0.86 (d, $J = 6.5$ Hz) [**2**: δ 0.91 (d, $J = 6.5$ Hz)]. All the above data, and the absence of any methylene group adjacent to

**1****2****3**

a neopentyl carbon (no triplet carbon signal below 32 ppm), indicated a sesquiterpene of the nardosinane series (3,4). Indeed, comparison of the ^1H - and ^{13}C -nmr data of **1** with published data, and especially the good agreement of the ^{13}C -nmr spectra of **1**, **3** (5), and **4** (6), unequivocally supported the nardosinane skeleton of **1**. The $\Delta^{1(10)}$ position of the double bond resulted from examination of literature data on compounds **4** (6) and **5** (7): **4** H-1 at δ 5.46 (m), C-1 δ 123.43 (d), and C-10 δ 141.34 (s), vs. **5** H-9 at δ 5.29 (d), C-9 δ 114.64 (d), and C-10 δ 148.44 (s). The axial orientation of the angular methyl group was deduced from its carbon chemical shift (δ 21.36), and the coupling constant of the C-4 methine hydrogen in **2** (δ 2.51, $J = 6.5, 6.5$, and 2 Hz) was consistent with the equatorial orientation of the secondary methyl group. The deshielded position in **2** of the H-4 and the absence of interaction between the 4-Me group and the hydroxyl of **2** (^1H nmr) both indicated the axial orientation of the isopropanol moiety. Attempts to determine the stereochemistry at C-11 by spectral (nOe experiments on **1**) or by physico-chemical methods were unsuccessful. Thus, **1** should be represented as depicted [i.e., 11,12-epoxynardosin-1(10)-ene] without absolute stereochemical implications.



Nardosinane sesquiterpenes have been isolated from several soft corals (5-13) and from the Valerianaceae *Nardostachys chinensis* (14,15). This is the first nardosinane sesquiterpene found in a gorgonian and the first one devoid of an oxygen function at C-7. This work supports the existence of a nardosinane bearing an isopropyl-oxide group proposed

as a likely intermediate on the way from aristolene to the lemnalane sesquiterpenes of alcyonarians (5).

EXPERIMENTAL

GENERAL EXPERIMENTAL PROCEDURES.—Optical rotations were measured with a Perkin-Elmer 241 polarimeter. Ir spectra were recorded as films on a Perkin-Elmer 137 spectrophotometer. ^1H - and ^{13}C -nmr spectra were obtained on a Varian XL-100 spectrometer at 100 and 25.2 MHz, respectively, using TMS as internal standard. Mass spectra were measured on a Micromass MM12F instrument. For cc Merck Kieselgel 60 was used. Analytical tlc was performed on Merck HF254 plates; spot detection was obtained by spraying with a 2% solution of $\text{Ce}(\text{SO}_4)_2$ in H_2SO_4 followed by heating 5 min at 150° . Mp's are uncorrected.

COLLECTION AND ISOLATION PROCEDURES.—*P. dilatata* was collected by scuba diving at a depth of 4-10 m at Praia do Forno, Arraial do Cabo, State of Rio de Janeiro, Brazil; at Praia Rasa, Búzios, State of Rio de Janeiro, Brazil; at Três Ilhas, Guarapará, State of Espírito Santo, Brazil; and at Santa Barbara Island, Abrolhos, State of Bahia, Brazil. Identification was made by Dr. Antônio M. Solé-Cava (Department of General Biology, Universidade Federal Fluminense, Brazil). Voucher specimens (dried, in EtOH or in formalin) were deposited in the marine invertebrate collection of our department under the numbers G-22/76, A-008/77, CF-81/82, G-101/86, and B(I)-02/89. Compound **1** was detected by tlc in all the collections and obtained pure from CF-81/82, G-101/85, and B(I)-02/89. A typical extraction is described.

Air-dried material (0.5 kg) was exhaustively extracted in a Soxhlet apparatus with hexane (3 liters). Evaporation of the solvent under reduced pressure afforded an oily residue (17.1 g) of which a 5-g aliquot was partitioned between hexane and 5% aqueous MeOH. The hexane layer (1.1 g) was subjected to cc on Si gel eluted with pure CH_2Cl_2 . The fractions containing **1** by tlc (694 mg) were combined and further purified by Si gel cc eluted with a gradient of EtOAc in hexane from 0 to 5%. The fractions eluted with hexane-EtOAc (98:2) (185 mg) were combined and finally purified by preparative tlc [eluent: hexane-EtOAc (95:5)] to afford **1** (125 mg) as a colorless odoriferous oil. Overall yield was 0.09% based on dried gorgonian.

11,12-EPOXYNARDOSIN-1(10)-ENE [1].— $[\alpha]_D^{25}$ -62.0 (589 nm), -64.8 (578), -74.4 (546), -133.8 (436), and -225.1 (365) ($c = 1.00$, CHCl_3); ir ν_{max} (film) 2915, 1450, 1370, 1275, 1240, 1180, 1060, 1045, 995,

903, 895, 835, 810, 788 cm^{-1} ; ms m/z (rel. int.): $[\text{M}]^+$ ($\text{C}_{15}\text{H}_{24}\text{O}$) 220 (26), 205 (17), 202 (22), 190 (86), 188 (28), 163 (83), 147 (89), 135 (45), 133 (45), 107 (100); ^1H nmr (CDCl_3 , 100 MHz) δ 0.86 (3H, d, $J = 6.5$ Hz), 1.04 (3H, s), 1.39 (3H, s), 2.57 (1H, d, $J = 6.5$ Hz), 2.75 (1H, d, $J = 6.5$ Hz), 5.45 (1H, m, $W_{1/2} = 11$ Hz); ^{13}C nmr (CDCl_3 , 25.2 MHz) 141.05 (s), 121.86 (d), 59.87 (t), 58.99 (s), 49.03 (d), 40.28 (s), 34.47 (d), 31.62 (t), 27.75 (t), 25.69 (t), 23.88 (t), 23.29 (t), 21.36 (q), 20.59 (q), 16.52 (q) ppm.

REDUCTION OF 2.—Epoxy **1** (46 mg), in THF (5 ml), was refluxed during 3 h in the presence of an excess of LiAlH_4 . The medium was then allowed to cool, and EtOAc , EtOH , H_2O , and H_2SO_4 (2 ml) were added successively. Extraction with CHCl_3 and evaporation of the dried (MgSO_4) organic layer afforded crude **2**. Purification by preparative tlc [eluent: hexane- EtOAc (88:12), two elutions] furnished pure **2** (38 mg, yield 81%) that crystallized from CHCl_3 .

11-HYDROXYNARDOSIN-1(10)-ENE [2].—Mp 86–88°; ir ν max (film) 3400, 2915, 1460, 1370, 1160, 1130, 1120, 957, 922, 872, 860, 833, 802 cm^{-1} ; ms m/z (rel. int.) $[\text{M} - \text{H}_2\text{O}]^+$ 204 (41), 189 (57), 161 (46), 149 (26), 122 (42), 107 (34), $[\text{COH}(\text{Me})_2]^+$ 59 (100); ^1H nmr (CDCl_3 , 100 MHz) δ 0.91 (3H, d, $J = 6.5$ Hz), 1.07 (3H, s), 1.32 (3H, s), 1.36 (3H, s), 2.51 (1H, ddq, $J = 2, 6.5, 6.5$ Hz), 5.42 (1H, m, $W_{1/2} = 10$ Hz); ^1H nmr (C_6D_6 , 100 MHz) δ 0.94 (3H, d, $J = 6.5$ Hz), 1.02 (3H, s), 1.18 (3H, s), 1.36 (3H, s), 2.65 (1H, ddq, $J = 2, 6.5, 6.5$ Hz), 5.35 (1H, m, $W_{1/2} = 10$ Hz).

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