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BRIARANE-TYPE DITERPENOIDS FROM THE GORGONIAN CORAL *Verrucella umbraculum*

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It is well known that the gorgonian corals have yielded a variety of bioactive natural compounds, most of which show a wide variety of biological activities [1]. Many briarane-related natural products, which are mostly characterized by the presence of a γ-lactone fused to a bicyclo[8.4.0] ring system, have been isolated from various octocorals, belonging mainly to the order Gorgonacea, including *Briareum* sp., *B. excavatum*, *B. polyanthes*, *Ellisella robusta*, *Gorgonella umbraculum*, *Junceella fragilis*, *J. juncea*, and *Subergorgia reticulata*; the order Pennatulacea, including *Renilla reniformis*; and the order Stolonifera, including *Pachyclavularia* sp., *P. violacea* [2–4].

Gorgonian coral of the genus *Verrucella* belongs to the family Ellisellidae. To date, little is known about *V. umbraculum* secondary metabolites except for two reports [5, 6]. To our knowledge, there are no reports regarding briarane-related diterpenoids from *V. umbraculum*.

V. umbraculum (3 kg, wet wt.) was extracted with ethanol (95%). Ethanol was evaporated *in vacuo* to afford a syrupy residue that was suspended in distilled water and fractionated successively with petroleum ether, ethyl acetate, and *n*-butanol. Rechromatography of the ethyl acetate fraction over silica gel and Sephadex LH-20 columns and ODS HPLC produced compounds **1–6**. The six compounds were identified as robustolide A (**1**) [7], renillafoulin A (**2**) [8], erythrolide B (**3**) [9], 4-deacetyljunceellolide D (**4**) [10], junceellonoid D (**5**) [11], and frajunolide A (**6**) [12], respectively, on the basis of their ^{1}H NMR and ^{13}C NMR spectra, and by comparison of their data with those reported previously in the related literature. All the compounds were isolated from *V. umbraculum* for the first time.

Robustolide A (1). Colorless oil. ^{1}H NMR (500 MHz, $CDCl_3$, δ, ppm, J/Hz): 5.80 (1H, s, H-9), 5.65 (1H, d, J = 7.5, H-2), 5.52 (1H, s, H-16), 5.27 (1H, s, H-17), 5.13 (1H, s, H-6), 5.01 (1H, s, H-7), 4.95 (1H, s, H-20a), 4.88 (1H, s, H-14), 4.43 (1H, s, H-20b), 3.47 (1H, s, H-10), 2.60 (2H, m, H-3), 2.34 (2H, m, H-13), 2.16 (3H, s, OAc), 2.05 (2H, m, H-4), 2.03 (3H, s, OAc), 2.02 (3H, s, OAc), 1.81 (2H, m, H-12), 1.38 (3H, d, J = 7.0, Me-18), 1.04 (3H, s, Me-15). ^{13}C NMR (125 MHz, $CDCl_3$, δ, ppm): 174.0 (C-19), 170.9 (OAc), 170.4 (OAc), 169.9 (OAc), 149.6 (C-11), 149.6 (C-5), 120.5 (C-16), 109.5 (C-20), 82.0 (C-8), 78.0 (C-7), 75.6 (C-9), 74.7 (C-14), 74.2 (C-2), 50.6 (C-6), 48.3 (C-1), 43.0 (C-10), 43.0 (C-17), 33.3 (C-13), 31.9 (C-3), 30.3 (C-4), 27.4 (C-12), 21.8 (OAc), 21.2 (OAc), 21.1 (OAc), 15.7 (C-15), 8.6 (Me-18).

Renillafoulin A (2). Colorless oil. ^{1}H NMR (500 MHz, $CDCl_3$, δ, ppm, J/Hz): 6.11 (1H, s, H-14), 5.98 (1H, s, H-13), 5.66 (1H, d, J = 9.7, H-6), 5.32 (1H, d, J = 6.0, H-9), 5.27 (1H, d, J = 9.7, H-7), 4.85 (1H, br.s, H-2), 3.43 (1H, d, J = 6.0, H-10), 2.60 (2H, m, H-3), 2.47 (2H, d, J = 7.0, H-17), 2.20 (3H, s, OAc), 2.05 (2H, m, H-4), 1.98 (3H, s, Me-16), 1.91 (3H, s, OAc), 1.36 (3H, s, Me-20), 1.26 (3H, s, Me-15), 1.11 (3H, d, J = 7.0, Me-18). ^{13}C NMR (125 MHz, $CDCl_3$, δ, ppm): 200.7 (C-12), 184.1 (C-19), 170.5 (OAc), 169.7 (OAc), 139.8 (C-14), 136.6 (C-5), 120.5 (C-6), 117.6 (C-13), 82.7 (C-8), 78.8 (C-2), 74.7 (C-7), 69.9 (C-9), 66.6 (C-11), 46.9 (C-1), 42.6 (C-17), 42.0 (C-10), 29.1 (C-3), 26.9 (C-4), 26.8 (C-16), 21.8 (OAc), 21.2 (OAc), 16.6 (C-20), 15.7 (C-15), 7.2 (Me-18).

Erythrolide B (3). Colorless oil. ^{1}H NMR (500 MHz, $CDCl_3$, δ, ppm, J/Hz): 7.39 (1H, d, J = 5.5, H-14), 5.98 (1H, d, J = 5.5, H-13), 5.80 (1H, s, H-16a), 5.65 (1H, d, J = 7.5, H-4), 5.64 (1H, d, J = 6.0, H-2), 5.52 (1H, s, H-7), 5.35 (1H, d,

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J = 6.0, H-3), 5.32 (1H, d, J = 6.0, H-9), 4.93 (1H, s, H-16b), 3.43 (1H, d, J = 6.0, H-10), 2.47 (2H, d, J = 7.0, H-17), 2.20 (3H, s, OAc), 2.03 (3H, s, OAc), 2.00 (3H, s, OAc), 1.50 (3H, s, Me-20), 1.26 (3H, s, Me-15), 1.11 (3H, d, J = 7.0, Me-18). ^{13}C NMR (125 MHz, $CDCl_3$, δ, ppm): 198.7 (C-12), 173.8 (C-19), 170.9 (OAc), 170.4 (OAc), 169.9 (OAc), 161.6 (C-14), 149.6 (C-2), 134.3 (C-5), 121.4 (C-3), 119.5 (C-13), 109.5 (C-16), 82.0 (C-8), 78.8 (C-11), 75.6 (C-4), 74.7 (C-7), 71.8 (C-9), 50.0 (C-6), 48.3 (C-1), 42.9 (C-17), 42.0 (C-10), 21.8 (OAc), 20.9 (OAc), 19.4 (OAc), 14.3 (C-20), 13.9 (C-15), 8.6 (Me-18).

4-Deacetyljunceellolide D (4). Colorless oil. ^{1}H NMR (500 MHz, $CDCl_3$, δ, ppm, J/Hz): 6.00 (1H, d, J = 10.0, H-6), 5.60 (1H, d, J = 10.0, H-7), 5.24 (1H, d, J = 5.4, H-9), 5.15 (1H, s, H-20a), 5.09 (1H, s, H-20b), 4.97 (1H, br.s, H-2), 4.78 (1H, br.s, H-14), 4.38 (1H, m, H-4), 3.43 (1H, d, J = 5.4, H-10), 2.70 (2H, m, H-3), 2.47 (2H, d, J = 7.0, H-17), 2.24 (2H, m, H-13), 2.20 (3H, s, OAc), 2.05 (2H, m, H-4), 2.01 (3H, s, OAc), 1.98 (3H, s, Me-16), 1.91 (3H, s, OAc), 1.81 (2H, m, H-12), 1.16 (3H, s, Me-15), 1.11 (3H, d, J = 7.0, Me-18). ^{13}C NMR (125 MHz, $CDCl_3$, δ, ppm): 173.0 (C-19), 170.4 (OAc), 170.3 (OAc), 169.5 (OAc), 150.1 (C-11), 145.3 (C-5), 120.5 (C-6), 113.2 (C-20), 83.1 (C-8), 76.8 (C-7), 73.9 (C-14), 72.3 (C-2), 71.4 (C-9), 71.3 (C-4), 46.9 (C-1), 42.6 (C-17), 42.0 (C-10), 31.2 (C-13), 29.1 (C-3), 26.8 (C-16), 26.4 (C-12), 21.8 (OAc), 21.2 (OAc), 21.1 (OAc), 15.7 (C-15), 6.4 (Me-18).

Junceellonoid D (5). Colorless oil. ^{1}H NMR (500 MHz, $CDCl_3$, δ, ppm, J/Hz): 5.85 (1H, s, H-16a), 5.63 (1H, s, H-9), 5.47 (1H, s, H-16b), 5.23 (1H, s, H-6), 5.24 (1H, s, H-14), 5.06 (1H, s, H-20a), 4.95 (1H, s, H-20b), 4.50 (1H, d, J = 7.0, H-7), 4.33 (1H, m, H-3), 4.16 (1H, d, J = 7.1, H-2), 4.05 (1H, d, J = 10.0, H-7), 3.10 (1H, s, H-17), 2.93 (1H, s, H-10), 2.34 (2H, m, H-13), 2.16 (3H, s, OAc), 2.03 (3H, s, OAc), 1.81 (2H, m, H-12), 1.48 (3H, d, J = 7.0, Me-18), 1.04 (3H, s, Me-15). ^{13}C NMR (125 MHz, $CDCl_3$, δ, ppm): 174.5 (C-19), 172.5 (OAc), 169.9 (OAc), 149.6 (C-11), 135.1 (C-5), 118.9 (C-16), 116.6 (C-20), 82.5 (C-8), 82.1 (C-4), 79.2 (C-7), 78.1 (C-9), 72.0 (C-2), 64.5 (C-3), 54.6 (C-6), 49.3 (C-1), 49.0 (C-17), 43.6 (C-10), 32.7 (C-13), 27.9 (C-12), 27.4 (C-14), 21.5 (OAc), 21.2 (OAc), 14.3 (C-15), 7.4 (Me-18).

Frajunolide A (6). Colorless oil. ^{1}H NMR (500 MHz, $CDCl_3$, δ, ppm, J/Hz): 5.70 (1H, d, J = 9.7, H-6), 5.37 (1H, d, J = 6.0, H-9), 5.32 (1H, d, J = 7.7, H-12), 5.27 (1H, d, J = 9.7, H-7), 5.19 (1H, s, H-20a), 5.06 (1H, s, H-20b), 4.80 (1H, br.s, H-2), 4.66 (1H, br.s, H-14), 3.44 (1H, d, J = 6.0, H-10), 2.50 (2H, m, H-3), 2.47 (2H, d, J = 7.0, H-17), 2.34 (2H, m, H-13), 2.20 (3H, s, OAc), 2.05 (2H, m, H-4), 2.01 (3H, s, OAc), 1.98 (3H, s, Me-16), 1.91 (3H, s, OAc), 1.90 (3H, s, OAc), 1.26 (3H, s, Me-15), 1.11 (3H, d, J = 7.0, Me-18). ^{13}C NMR (125 MHz, $CDCl_3$, δ, ppm): 176.0 (C-19), 170.4 (OAc), 170.4 (OAc), 170.2 (OAc), 169.5 (OAc), 149.1 (C-11), 145.3 (C-5), 120.5 (C-6), 113.2 (C-20), 83.1 (C-8), 78.2 (C-2), 77.3 (C-7), 74.4 (C-14), 71.4 (C-9), 68.4 (C-12), 46.9 (C-1), 42.5 (C-17), 42.0 (C-10), 33.2 (C-13), 31.1 (C-3), 28.9 (C-4), 26.8 (C-16), 21.8 (OAc), 21.2 (OAc), 21.1 (OAc), 21.0 (OAc), 15.7 (C-15), 6.6 (Me-18)

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REFERENCES

1. J. W. Blunt, B. R. Copp, M. H. G. Munro, P. T. Northcote, and M. R. Prinsep, *Nat. Prod. Rep.*, **28** (2), 196 (2011).
2. P. J. Sung, J. H. Sheu, and J. P. Xu, *Heterocycles*, **57** (3), 535 (2002).
3. P. J. Sung, P. C. Chang, L. S. Fang, J. H. Sheu, W. C. Chen, Y. P. Chen, and M. R. Lin, *Heterocycles*, **65** (1), 195 (2005).
4. P. J. Sung, J. H. Sheu, W. H. Wang, L. S. Fang, H. M. Chung, C. H. Pai, Y. D. Su, W. T. Tsai, B. Y. Chen, M. R. Lin, and G. Y. Li, *Heterocycles*, **75** (11), 2627 (2008).
5. C. Y. Wang, L. L. Sun, C. L. Shao, W. L. Mei, H. Huang, and H. F. Dai, *Biochem. Syst. Ecol.*, **38** (5), 1085 (2010).
6. W. Wang, S. H. Xu, and X. J. Liao, *Chin. Pharm. J.*, **25** (3), 172 (2010).
7. P. J. Sung, W. T. Tsai, M. Y. Chiang, Y. M. Su, and J. Kuo, *Tetrahedron*, **63** (32), 7582 (2007).
8. M. B. Ksebati and F. J. Schmitz, *Bull. Soc. Chim. Belg.*, **95** (9–10), 835 (1986).
9. S. A. Look, W. Fenical, D. Vanengen, and J. Clardy, *J. Am. Chem. Soc.*, **106** (17), 5026 (1984).
10. M. Garcia, J. Rodriguez, and C. Jimenez, *J. Nat. Prod.*, **62** (2), 257 (1999).
11. S. H. Qi, S. Zhang, Y. M. Wen, Z. H. Xiao, and Q. X. Li, *Helv. Chim. Acta*, **88** (8), 2349 (2005).
12. Y. C. Shen, Y. H. Chen, T. L. Hwang, J. H. Guh, and A. T. Khalil, *Helv. Chim. Acta*, **90** (7), 1391 (2007).