Records of Natural Products

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SHORT REPORTS

A heptaketide compound isolated from endophytic fungus (*Mariannaea Superimposita*) of *Paris polyphylla* var. *yunnanensis*

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Abstract: A novel heptaketide compound (**1**), with twelve known compounds (**2**–**13**) were isolated from the solid fermentation product of the endophytic fungus *Mariannaea superimposita* obtained from *Paris polyphylla var. yunnanensis*. The chemical structure of compound **1** were determined through spectral analysis including 1D/2D NMR data and HR-ESIMS. The cytotoxicity of the six compounds (**1**–**6**) was tested against six tumor cell lines (MCF-7, A549, HepG2, SKOV3, MDA-MB-231, and 143B). Compound **1** effectively inhibited the growth of human cancer cell lines MCF-7, A549, HepG2, and MDA-MB-231. The mitochondrial membrane potential measurements indicate that compound **1** promotes the premature apoptosis of MDA-MB-231 cells in a dose-dependent manner.

Keywords: *Mariannaea superimposita*, heptaketide, anti-tumor, *Paris polyphylla var. yunnanensis*

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1 Fungal Source

The plant endophytic fungus *M. superimposita* was isolated from *P. polyphylla var. yunnanensis*, which was collected in Yunnan Province, China. The strain was identified using nuclear 18S rDNA sequences (GenBank: PX461201) (Nonaka et al., 2015). The fungus was preserved in the Natural Products Chemistry Laboratory, School of Chemistry and Chemical Engineering, Southeast University.

2 Previous Studies

Paris polyphylla var. *yunnanensis* (Franch.) Hand.-Mazz., a traditional Chinese medicine "Chonglou", is used to treat abscesses, sore throat, venomous snake bites, bruises, and convulsions (Zhang et al., 2025). The wild resources of *P. polyphylla* var. *yunnanensis* are facing severe depletion due to over-exploitation and environmental degradation (Chen et al., 2022) and has been listed as near threatened (NT) species in the IUCN. Therefore, cultivated varieties are commonly used in the traditional Chinese medicine system. However, cultivated varieties often exhibit limited accumulation of medicinal compounds and long growth cycles. The search for medicinal active ingredients from endophytic fungi in *P. polyphylla* var. *yunnanensis* has become a current research hotspot. The research indicates that studies on endophytic fungi in *P. polyphylla* var. *yunnanensis* based on secondary metabolites mainly focuses on several genera such as *Phomopsis* (Yang et al., 2017), *Fusarium* (Zhang et al., 2011), *Penicillium* (Li et al., 2017) and *Aspergillus* (Yan-Jun, 2020). *Mariannaea* genus is a rare fungal genus belonging to the Nectriaceae family, mainly isolated from soil and plants (Tani et al., 2025). The number of secondary metabolites isolated from the soil-derived *Mariannaea* fungi is limited, and reported compounds include prenylated phenylpropanoids (Fukuda et al., 2011), cyclic octapeptides (Ishiuchi et al., 2020), and γ-pyrone-type diterpenoids (Tani et al., 2025). However, a lack of reports exists regarding the secondary metabolites of Mariannaea fungi obtained from plants.

3 Present Study

The fermented rice material was crushed into small pieces and extracted three times with equal volumes of ethyl acetate (EtOAc), each extraction lasting three days. The collected extracts were subjected to vacuum distillation, yielding 60.5 g of crude extract. This crude extract was dispersed in distilled water and sequentially extracted five times with petroleum ether (PE) and ethyl acetate, respectively,

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Table 1. ^{1}H (600 MHz) and ^{13}C (150 MHz) NMR data of **1** in Dimethyl Sulfoxide-d_6

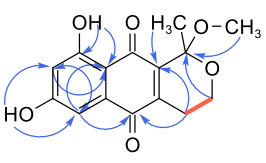
Position	δ_C	Type	δ_H, (mult,*J*)
1	96.7	C	
3	57.2	CH_2	4.58 (dd, *J* = 18.2, 3.0 Hz, β) 4.24 (dt, *J* = 18.8, 3.8 Hz, α)
4	32.3	CH_2	2.45 (m, α) 2.61 (dd, *J* = 18.9, 3.1 Hz, β)
4a	140.9	C	
5	182.4	C	
5a	133.4	C	
6	108.4	CH	6.93 (d, *J* = 2.36 Hz)
7	164.9	C	
8	107.2	CH	6.51 (d, *J* = 2.27 Hz)
9	163.5	C	
9a	107.8	C	
10	185.7	C	
10a	139.2	C	
1-OMe	48.3	CH_3	3.17 (s)
1-CH_3	22.4	CH_3	1.41 (s)
7-OH			11.23 (s)
9-OH			11.93 (s)

resulting in the PE extract (50.2 g) and the EtOAc extract (8 g). The EtOAc extract was separated by column chromatography on silica gel (200–300 mesh, Dichloromethane (DCM)/MeOH, 200:1 to 0:1, *v*/*v*) to generate eight fractions (Frs.1-8). Fr.6 was further separated using column chromatography on silica gel (200–300 mesh, DCM/MeOH, 50:1 to 1:1, *v*/*v*) to give Fr.6-1 to Fr.6-4, subsequently, subfraction Fr.6-2 (260 mg) was selected for separation and purification by semipreparative HPLC (MeCN/H_2O,60:40 to 95:5, 3 mL/min) to obtain compound **1** (3.5 mg, t_R = 12 min). Fr.6-3 (540 mg) was separated by semipreparative HPLC (MeCN/H_2O, 27:73 to 30:70, 3 mL/min) to yield compound **2** (50 mg, t_R = 10 min). Compound **5** (21.2 mg, t_R = 17.5 min) and Compound **8** (3.8 mg, t_R = 28.5 min) was isolated from Fr.6-4 (200 mg) by semipreparative HPLC (MeCN/H_2O, 20:80 to 40:60, 3 mL/min). Fr.2 was fractionated by silica gel column chromatography with a gradient of DCM−MeOH from 200:1 to 50:1 (v/v) to afford 11 subfraction (Frs.2-1 to 2-11), Fr.2-6 (28 mg) was purified by preparative TLC (DCM/MEOH, 100:1, *v*/*v*) to yield compound **3** (5.2 mg). Fr.5(1.0 g) was initially separated by the MCI GELCHP20P (MeOH/H_2O,1:1,v/v) to obtain three subfractions (Frs.5-1 to 5-3), Fr.5-1 (200 mg) was subjected to semipreparative HPLC (MeCN/H_2O, 30:70 to 45:55, 3 mL/min), resulting in the isolation of compound **4** (5.8 mg, t_R = 11.5 min), **6** (4.2 mg, t_R = 12.5 min), **7** (5.3 mg, t_R = 10 min), **11** (2.8 mg, t_R = 14 min), **12** (4.0 mg, t_R = 5 min). Fr.4-3 (200 mg) was separated by semipreparative HPLC (MeCN/H2O, 85:15 to 0:100, 3 mL/min) to yield Compound **9** (2.0 mg, t_R = 6.5 min) and Compound **10** (3.7 mg, t_R = 10 min). Compound **13** (5.6 mg, t_R = 26.5 min) was isolated from Fr.4-1 (650 mg) by semipreparative HPLC (MeCN/H_2O, 80:20 to 0:100, 3 mL/min).

Compound **1** (HPLC(purity): 97.4%): Purple-red powder. ^{1}H NMR (600 MHz, Dimethyl Sulfoxide-d6) and ^{13}C NMR (151 MHz, Dimethyl Sulfoxide-d6) data, see Table 1; IR (KBr) υ_{max} (cm^{-1}): 3412, 1648, 1621, 1407, 1327, 1176, 1160 and 1056; UV(MeOH) λ_{max} (log ε) 221.5 (3.09), 267.5 (2.47) and 357.5 (0.67) nM; HR-ESIMS *m*/*z*: 313.0679 [M + Na]$^+$ (calcd for $C_{15}H_{14}O_6Na^+$, 313.0683).

Compound **1** was obtained as a Purple-red powder. The molecular formular was determined to $C_{15}H_{14}O_6$, with 9 degrees of unsaturation, based on HR-ESIMS analysis (*m*/*z* 313.0679 [M + Na]$^+$, calcd for $C_{15}H_{14}NaO_6^+$, 313.0683). Its IR spectrum showed absorption at 3412 and 1648, 1621 cm^{-1}, indicating the presence of hydroxy group and carbonyls. The ^{1}H NMR (600 MHz) and ^{13}C NMR (150 MHz) data as shown in Table 1. The ^{1}H NMR data of **1** indicated the presence of two aromatic protons, H-6 (δ_H 6.93) and H-8 (δ_H 6.51), one methoxy group (δ_H 3.17) and one methyl group (δ_H 1.41), along with two hydroxyl hydrogen groups (δ_H 11.23 and δ_H 11.93). The ^{13}C NMR data of compound **1** revealed two significant carbonyl signals in the low field region. Further analysis of the DEPT-135 data and ^{13}C NMR data indicated that compound **1** contain nine quaternary carbons signals, together with two methine signals, two methylene signals, and two methyl signals. From the unsaturation analysis of the compound, the benzene ring contributes four unsaturation units, and the two carbonyl groups contribute two unsaturation units. One double bond was present in the ^{13}C NMR spectrum, and a single double bond contributes one unsaturation unit. Therefore, the compound retains two unsaturation units distributed as two six-membered rings.

The corresponding HMBC and HSQC spectra were used to assign the relevant carbon-hydrogen signals and determine the carbon signal assignments. The HSQC spectrum revealed the chemical shifts for the two benzene ring hydrogen signals and carbon signals as (δ_H 6.93, δ_C 108.4) and (δ_H 6.51, δ_C 107.2). In the HMBC spectrum, the carbonyl carbon at δ_C 182.4 ppm correlates with δ_H 6.93 (1H, m, H-6) and δ_H 2.61 (dd, *J* = 18.9, 3.1 Hz, H-4), However, C-10 shows no correlation in the HMBC spectrum, Thus, the carbonyl carbon at C-5 resonated at δ_C 182.4, while that at C-10 was observed at δ_C 185.7. Additionally, in HMBC, the methyl hydrogen (δ_H 1.41) correlates with C-10a (δ_C 139.2), while the methoxy (δ_H 3.17) correlates with C-1 (δ_C 96.7), further validating the substitution positions of the methyl and methoxy groups. The 9-OH (δ_H 11.93) is correlated with C-8 (δ_C 107.2), and C-9a (δ_C 107.8), while the 7-OH (δ_H 11.23) is correlated with



1

Figure 1. Key ^{1}H-^{1}H COSY and HMBC correlations of compound **1**

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C-8 (δ_C 107.2), and C-6 (δ_C 108.4), further confirming the substitution positions of the two hydroxyl groups. The ^{1}H-^{1}H COSY spectrum clearly reveals coupling between CH_2 (3) and CH_2 (4), further validating the backbone structure. The planar structure of compound **1** was established, as shown in Figure 1.

Moreover, the electronic circular dichroism (ECD) calculation was adopted to confirm the absolute configuration of compound **1** at the B3LYP/6-311++G (d, p) level. The experimental spectrum of compound **1** showed weak correlation with the calculated spectra of compound **1** (1R and 1S) (Fig. S13); it was therefore identified as a racemic mixture. In the ^{1}H–^{1}H NOESY spectrum, we observed correlations for both H-4β/H1-CH_3 and H-4α/H1-CH_3, indicating that H1-CH_3 is spatially close to protons on both faces at C-4. In addition, the CD signal of our sample is weak and largely canceling. Taken together, these observations support that compound **1** is more likely present as a racemic mixture. Unfortunately, the limited amount of compound **1** precluded further purification and determination of its absolute configuration. Ultimately, compound **1** has been determined as 7,9-dihydroxy-1-methoxy-1-methyl-3,4-dihydro-1H-benzo[*g*]isochromene-5,10-dione.

In addition to compound **1**, twelve known compounds, including 11*S*-1,3,6-trihydroxy-7-(1-hydroxyethyl) anthracene-9,10-dione (**2**) (Zhao et al., 2018), 6-deoxy-7-*O*-demethyl-3,4-anhydrofusarubin (**3**) (Thines et al., 1998), 7-Hydroxy-2,5-dimethylchromone (**4**) (Kametani et al., 2014), 2-(2-Hydroxypropyl)-5-methyl-7-hydroxychromone (**5**) (Gao et al., 2013), acrodontiolamide (**6**) (Abba et al., 2025), N-(2-Phenylethyl)acetamide (**7**) (Chen et al., 2018), 2,3-Bis(1,1-dimethylethyl)-5-benzofuranol (**8**) (Xu et al., 2023), p-hydroxyphenylacetamide (**9**) (Dantas et al., 2023), Ethyl 4-hydroxyphenylacetate (**10**) (Kang et al., 2010), Fusaritricin G (**11**) (Wan et al., 2025), phenyl acetic acid (**12**) (Gutierrez-Lugo et al., 2005) and (R)-3,4-Dihydro-4,8-dihydroxy-6-methoxy-4,5-dimethyl-3-methyleneisochromen-1-one (**13**) (Tayone et al., 2011) were isolated and identified by comparison of their spectroscopic data with the reported data. Additionally, twelve known compounds have been firstly isolated from fungus *M. superimposita* which was isolated from *P. polyphylla var. yunnanensis* (Figure 2).

As shown in Table 2, compounds **1**–**6** were evaluated for cytotoxic activity against six cancer cell lines (MCF-7, A549, HepG2, SKOV3, MDA-MB-231, and 143B cell lines) using the CCK-8 assay, with adriamycin as the positive control. The results indicated that six compounds exhibited varying degrees of cytotoxic activity against the six cancer cell lines. Compounds **1** and **5** exhibited effective cytotoxic activity against MCF-7 cells with IC_{50} values of 28.77 and 27.61 μM. For HepG2 and MDA-MB-231 cells, compound **1** exhibited stronger cytotoxicity than other compounds, with IC_{50} values of 34.28 and 29.93 μM, Compound **1** exhibited certain cytotoxicity toward cell lines such as MCF-7, A549, HepG2, and MDA-MB-231. Unfortunately, its cytotoxic effect is not as potent as that of adriamycin. As a result, as shown in Figure 3,

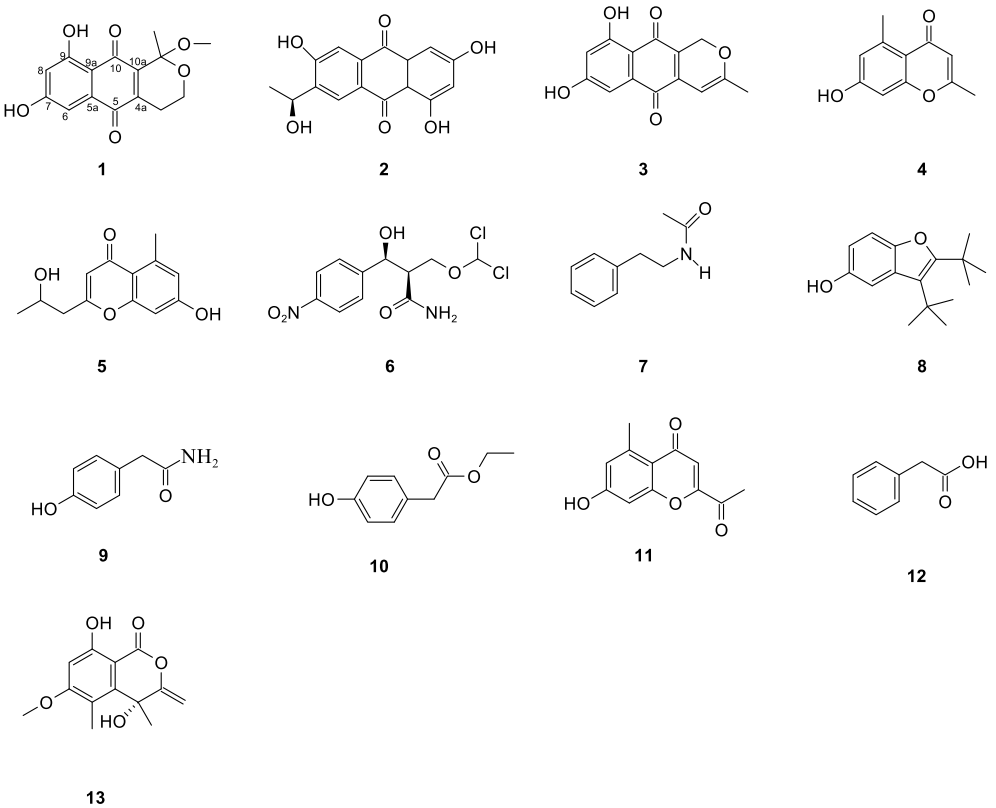


Figure 2. Structures of compounds **1**–**13**

Table 2. Cytotoxic assay of compounds **1**–**6** with IC_{50} values (μM)[a]

Compounds	MCF-7	A549	HepG2	SKOV3	MDA-MB-231	143B
1	28.77	29.61	34.28	57.26	29.93	65.22
2	60.49	65.90	58.55	74.83	55.45	84.67
3	80.44	28.68	50.08	44.70	53.04	93.13
4	44.00	55.50	49.82	>100	>100	100
5	27.61	47.16	38.77	35.62	34.52	49.80
6	50.79	32.98	64.77	43.77	49.12	>100
adriamycin b	2.81	5.93	7.35	6.12	5.70	9.34

Note: [a]The values presented are the mean of triplicate experiments. [b]The positive control.

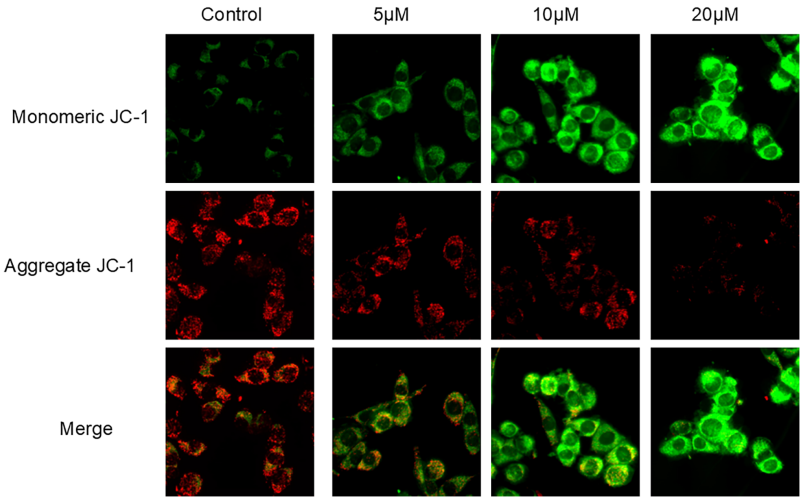


Figure 3. Compound **1** mitochondrial membrane potential by JC-1 dye in MDA-MB-231 cells

As the dose increases (5, 10, 20 μM), the red fluorescence progressively diminishes and the green fluorescence of the cells gradually increased. These results indicate that compound **1** promotes the premature apoptosis of MDA-MB-231 cells in a dose-dependent manner.

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Author Contributions

Chao Wang: Data curation, Formal analysis, Visualization, Writing—original draft and Writing—review & editing. Yu Zhang: Investigation, Chen-Sen Xu: Methodology, Hao-Lin Yu: Supervision, Jing Zhang: Validation, Yi-Lin Liu: Supervision, Yi-Bo Shen: Validation, Chao Liu: Project administration, Jin-Zhong Hu: Project administration, Zhi-Xin Liao: Conceptualization, Funding acquisition, Resources and Writing—review & editing.

Availability of Data and Materials

The authors declare that the data supporting the findings of this study are available within the paper and its Supplementary Information files. Should any raw data files be needed in another format they are available from the corresponding author upon reasonable request. Source data are provided with this paper.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supporting Information

Supporting Information accompanies this paper on http://www.acgpubs.org/journal/records-of-natural-products.

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References

Abba, C. C., Eze, P. M., Ebada, S. S., Eze, N. K., Proksch, P., Teusch, N., Okoye, F. B. C. & Eboka, C. J. (2025). Rare chlorinated fungal metabolite and alpha-pyrones from an endophytic fungus Nigrospora sp. *ACS Omega*, *10*(6), 5722–5729. DOI: 10.1021/acsomega.4c09190.

Chen, S., Yong, T., Xiao, C., Su, J., Zhang, Y., Jiao, C. & Xie, Y. (2018). Pyrrole alkaloids and ergosterols from Grifola frondosa exert anti-α-glucosidase and anti-proliferative activities. *Journal of Functional Foods*, *43*, 196–205. DOI: 10.1016/j.jff.2018.02.007.

Chen, Y., Yu, D., Huo, J., Huang, N., Zhang, M. & Du, X. (2022). Studies on biotransformation mechanism of Fusarium sp. C39 to enhance saponin content of Paridis Rhizoma. *Frontiers in Microbiology*, *13*, 366. DOI: 10.3389/fmicb.2022.992318.

Dantas, S. B. S., Moraes, G. K. A., Araujo, A. R. & Chapla, V. M. (2023). Phenolic compounds and bioactive extract produced by endophytic fungus Coriolopsis rigida. *Natural Product Research*, *37*(12), 2037–2042. DOI: 10.1080/14786419.2022.2115492.

Fukuda, T., Sudoh, Y., Tsuchiya, Y., Okuda, T., Fujimori, F. & Igarashi, Y. (2011). Marianins A and B, Prenylated Phenylpropanoids from Mariannaea camptospora. *Journal of Natural Products*, *74*(5), 1327–1330. DOI: 10.1021/np200035m.

Gao, L., Xu, X. & Yang, J. (2013). Chemical constituents of the roots of Rheum officinale. *Chemistry of Natural Compounds*, *49*(4), 603–605. DOI: 10.1007/s10600-013-0689-7.

Gutierrez-Lugo, M. T., Woldemichael, G. M., Singh, M. P., Suarez, P. A., Maiese, W. M., Montenegro, G. & Timmermann, B. N. (2005). Isolation of three new naturally occurring compounds from the culture of Micromonospora sp. P1068. *Natural Product Research*, *19*(7), 645–652. DOI: 10.1080/14786410412331272040.

Ishiuchi, K.i, Hirose, D., Kondo, T., Watanabe, K., Terasaka, K. & Makino, T. (2020). Mariannamides A and B, new cyclic octapeptides isolated from Mariannaea elegans NBRC102301. *Bioorganic & Medicinal Chemistry Letters*, *30*(4), 126946. DOI: 10.1016/j.bmcl.2019.126946.

Kametani, S., Kojima-Yuasa, A., Kikuzaki, H., Kennedy, D. O., Honzawa, M. & Matsui-Yuasa, I. (2014). Chemical constituents of Cape Aloe and their synergistic growth-inhibiting effect on Ehrlich ascites tumor cells. *Bioscience, Biotechnology, and Biochemistry*, *71*(5), 1220–1229. DOI: 10.1271/bbb.60659.

Kang, D. W., Kim, Y. S., Lim, K. S., Kim, M. S., Pearce, L. V., Pavlyukovets, V. A., Tao, A. K., Lang-Kuhs, K. A., Blumberg, P. M. & Lee, J. (2010). Halogenation of 4-hydroxy/amino-3-methoxyphenyl acetamide TRPV1 agonists showed enhanced antagonism to capsaicin. *Bioorganic & Medicinal Chemistry*, *18*(22), 8092–8105. DOI: 10.1016/j.bmc.2010.09.001.

Li, X-Z., Ruan, B-H., Yang, Y-B., Yang, X-Q., Chen, G-Y., Hu, M., Wang, B-Y., Zhou, H. & Ding, Z-T. (2017). Metabolites from Penicillium sp. associated with Paris polyphylla. *Natural Product Communications*, *12*(1), 87–88. DOI: 10.1177/1934578x1701200124.

Nonaka, K., Kaneta, T., Ōmura, S. & Masuma, R. (2015). Mariannaea macrochlamydospora, a new hyphomycete (Nectriaceae) from soil in the Bonin Islands, Japan. *Mycoscience*, *56*(1), 29–33. DOI: 10.1016/j.myc.2014.02.001.

Tani, K., Wakatsuki, M., Wada, M., Nonaka, K., Kikuchi, Y., Kimura, S.-i, Watanabe, Y., Hokari, R., Hirose, T., Honsho, M., Asami, Y., Tsutsumi, H., Inahashi, Y., Iwatsuki, M., Matsui, H., Sunazuka, T., Hanaki, H., Teruya, T. & Ishii, T. (2025). Discovery of structurally diverse γ-Pyrone-type diterpenoids produced by the Fungus Mariannaea sp. FKR-1011 from Zamami Island. *Journal of Natural Products*, *88*(8), 1871–1878. DOI: 10.1021/acs.jnatprod.5c00223.

Tayone, W. C., Honma, M., Kanamaru, S., Noguchi, S., Tanaka, K., Nehira, T. & Hashimoto, M. (2011). Stereochemical investigations of isochromenones and isobenzofuranones isolated from Leptosphaeria sp. KTC 727. *Journal of Natural Products*, *74*(3), 425–429. DOI: 10.1021/np100838j.

Thines, E., Anke, H. & Sterner, O. (1998). Trichoflectin, a bioactive azaphilone from the ascomycete Trichopezizella nidulus. *Journal of Natural Products*, *61*(2), 306–308. DOI: 10.1021/np970469g.

Wan, X.-R., Li, C., Liu, L.-Y., Yue, F., Lu, X., Pei, Y.-H. & Yang, Y.-H. (2025). Fusaritricins E–G, three new polyketides, isolated from the endophytic fungus Fusarium sp. HC20 and their antifungal activities. *Phytochemistry Letters*, *69*, 103016. DOI: 10.1016/j.phytol.2025.103016.

Xu, N., Nyamdavaa, E., Yu, J., Xiao, H., Liu, J., Li, S. & Xu, L. (2023). A new benzofuran compound from the resinous exudates of Commiphora myrrha. *Natural Product Research*, *37*(9), 1416–1420. DOI: 10.1080/14786419.2021.2011272.

Yan-Jun, H. Y.-T Y. H.-M C. (2020). A new polyketide from endophytic fungus Aspergillus oryzae derived from Paris polyphylla var. yunnanensis. *Chinese Herbal Medicines*, *51*(17), 4393–4396. DOI: 10.7501/j.issn.0253-2670.2020.17.004.

Yang, H.-Y., Duan, Y.-Q., Yang, Y.-K., Li, J., Liu, X., Ye, L., Mi, Q.-L., Kong, W.-S., Zhou, M., Yang, G.-Y., Li, X.-M. & Hu, Q.-F. (2017). Three new napthalene derivatives from the endophytic fungus Phomopsis fukushii. *Phytochemistry Letters*, *22*, 266–269. DOI: 10.1016/j.phytol.2017.10.021.

Zhang, Y., Fan, Y.-C., Zhang, Y.-C., Li, Q., Su, Y.-Y., Xu, C.-S., Yu, H.-L., Wang, C., Zhang, J. & Liao, Z.-X. (2025). Antitumor activity and mechanistic study of steroidal saponins from the rhizomes of Paris polyphylla var. yunnanensis. *Phytochemistry*, *235*, 114455. DOI: 10.1016/j.phytochem.2025.114455.

Zhang, Y., Zhao, J., Wang, J., Shan, T., Mou, Y., Zhou, L. & Wang, J. (2011). Chemical composition and antimicrobial activity of the volatile oil from Fusarium tricinctum, the endophytic fungus in Paris polyphylla var. yunnanensis. *Natural Product Communications*, *6*(11), 1759–1762. DOI: 10.1177/1934578x1100601146.

Zhao, D.-L., Wang, D., Tian, X.-Y., Cao, F., Li, Y.-Q. & Zhang, C.-S. (2018). Anti-phytopathogenic and cytotoxic activities of crude extracts and secondary metabolites of marine-derived fungi. *Marine Drugs*, *16*(1), 36. DOI: 10.3390/md16010036.