

Diversity and bioactivity of endolichenic fungi in *Usnea* lichens of the Philippines

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Identified endolichenic fungi and their GenBank accession numbers by lichen host, with the closest GenBank ITS sequences

Lichen host	ELF taxon	GenBank accession number	Length (bp)	Closest GenBank ITS sequence	Culture collection code	Sequencing similarity (%)	Species	Reference
<i>Usnea baileyi</i>	<i>Daldinia</i> sp.	MN153499	579	MN341735.1	KoRLI046083	100	<i>Daldinia</i> sp.	Oh et al. 2020
	<i>Fusarium</i> sp.	–	642	MT447544.1	GFR39	76.21	<i>Fusarium proliferatum</i>	Yang 2020*
	<i>Kretzschmaria pavimentosa</i>	MN071368	602	MF770841.1	FS75	99.83	<i>Kretzschmaria pavimentosa</i>	Vandegrift et al. 2017*
	<i>Kretzschmaria pavimentosa</i>	MN071357	599	MF770841.1	FS75	100	<i>Kretzschmaria pavimentosa</i>	Vandegrift et al. 2017*
	<i>Nemania bipapillata</i>	MW079959	625	MG881836.1	EF24	99.84	<i>Nemania bipapillata</i>	Santiago et al. 2018*
	<i>Nemania bipapillata</i>	MN636329	601	JQ341104.1	D2c2a	99.67	<i>Nemania bipapillata</i>	Douanla-Meli et Langer 2012
	<i>Nemania bipapillata</i>	MN613131	575	MF770848.1	FS123	94.13	<i>Nemania bipapillata</i>	Vandegrift et al. 2017*
	<i>Nemania bipapillata</i>	MN071353	583	JQ341104.1	D2c2a	99.48	<i>Nemania bipapillata</i>	Douanla-Meli et Langer 2012
	<i>Nemania bipapillata</i>	MN613124	615	MG881836.1	EF24	99.67	<i>Nemania bipapillata</i>	Santiago et al. 2018*
	<i>Nemania bipapillata</i>	MN071354	569	MG881836.1	EF24	99.30	<i>Nemania bipapillata</i>	Santiago et al. 2018*
	<i>Nemania bipapillata</i>	MN613129	618	MG881836.1	EF24	99.84	<i>Nemania bipapillata</i>	Santiago et al. 2018*
	<i>Nemania bipapillata</i>	MN545822	575	MF770848.1	FS123	94.13	<i>Nemania bipapillata</i>	Vandegrift et al. 2017*
	<i>Nemania bipapillata</i>	MN545841	616	MG881836.1	EF24	99.35	<i>Nemania bipapillata</i>	Santiago et al. 2018*
	<i>Nemania diffusa</i>	MN613127	594	LC505268.1	My-BL71	96.30	<i>Nemania diffusa</i>	Osono et al. 2020
	<i>Nemania diffusa</i>	MN613138	589	KY951906.1	MoEF011	99.66	<i>Nemania diffusa</i>	Wang et al. 2018
	<i>Nemania diffusa</i>	MN545823	598	MF770849.1	FS112	96.49	<i>Nemania</i> sp. ‘ <i>diffusa</i> var. 1’	Vandegrift et al. 2017*
	<i>Nemania diffusa</i>	MW079956	599	KY951906.1	MoEF011	99.50	<i>Nemania diffusa</i>	Wang et al. 2018
	<i>Nemania diffusa</i>	MN071372	588	MN341763.1	KoRLI046053	99.82	<i>Nemania diffusa</i>	Oh et al. 2020
	<i>Nodulisporium</i> sp.	MN545830	598	MN341806.1	KoRLI046261	98.63	<i>Nodulisporium</i> sp.	Oh et al. 2020
	<i>Nodulisporium</i> sp.	MN545824	593	MN341806.1	KoRLI046261	99.66	<i>Nodulisporium</i> sp.	Oh et al. 2020
				MG832472.1	TS-52	99.48		Pan et al. 2018*
				GQ906963.1	JW89-5	99.48		Li et al. 2009*
	<i>Nodulisporium</i> sp.	MN613120	607	GQ906963.1	JW89-5	96.59	<i>Nodulisporium</i> sp.	Li et al. 2009*
	<i>Penicillium simplicissimum</i>	MW079964	593	KM104578.1	PBL3	100	<i>Penicillium simplicissimum</i>	Chow et Ting 2014
	<i>Xylaria apiculata</i>	MN613134	608	KP133336.1	24.1.1	99.51	<i>Xylaria apiculata</i>	Thomas et al. 2014*
				KX960798.1	Edf-13	99.50		Shan 2016*
	<i>Xylaria atosphaerica</i>	MN545826	584	GU322459.1	91111214	99.28	<i>Xylaria atosphaerica</i>	Hsieh et al. 2010
	<i>Xylaria</i> cf. <i>heliscus</i>	MW330005	911	GU324742.1	88113010	98.36	<i>Xylaria</i> cf. <i>heliscus</i>	Hsieh et al. 2010
	<i>Xylaria</i> cf. <i>heliscus</i>	MW330003	911	GU324742.1	88113010	98.36	<i>Xylaria</i> cf. <i>heliscus</i>	Hsieh et al. 2010
	<i>Xylaria venustula</i>	MN545818	612	GU300091.1	88113002	99.66	<i>Xylaria venustula</i>	Hsieh et al. 2010
				KJ572202.1	YN31	99.83		Min 2014*
	<i>Xylaria venustula</i>	MN636328	620	GU300091.1	88113002	99.50	<i>Xylaria venustula</i>	Hsieh et al. 2010
				KJ572202.1	YN31	99.65		Min 2014*
	<i>Xylaria venustula</i>	MH370742	591	GU300091.1	88113002	99.49	<i>Xylaria venustula</i>	Hsieh et al. 2010
				KJ572202.1	YN31	99.65		Min 2014*

Lichen host	ELF taxon	GenBank accession number	Length (bp)	Closest GenBank ITS sequence	Culture collection code	Sequencing similarity (%)	Species	Reference
<i>Usnea bismolliuscula</i>	<i>Annulohypoxylon albidiscum</i>	MW079961	640	KU852741.1	MFLUCC 15-0645	98.80	<i>Annulohypoxylon albidiscum</i>	Li et al. 2016
	<i>Astrocystis bambusae</i>	MH370741	618	KP401580.1	EK14005	99.68	<i>Astrocystis bambusae</i>	Sir et al. 2015
	<i>Daldinia eschscholtzii</i>	MN613135	587	MH793588.1	AgF4-29-4	99.83	<i>Daldinia eschscholtzii</i>	Lee et Kirschner 2018*
	<i>Diaporthe longicolla</i>	MN545819	599	MG661722.1	ISE014	99.15	<i>Diaporthe longicolla</i>	Raffi 2017*
	<i>Fusarium proliferatum</i>	MN545834	598	MH055399.1	DSM 106835	99.50	<i>Fusarium proliferatum</i>	Alwahshi et al. 2019
	<i>Kretzschmaria pavimentosa</i>	MN545838	598	MF770841.1	FS75	100	<i>Kretzschmaria pavimentosa</i>	Vandegrift et al. 2017*
	<i>Nemania bipapillata</i>	MN071362	615	MG881836.1	EF24	100	<i>Nemania bipapillata</i>	Santiago et al. 2018*
				GU292818.1	90080610	99.66		Hsieh et al. 2010
	<i>Nemania bipapillata</i>	MN071375	614	JQ341104.1 JQ341103.1	D2c2a D12a2	99.51 99.35	<i>Nemania bipapillata</i>	Douanla-Meli et Langer 2012
	<i>Nemania bipapillata</i>	MN545825	612	MG881836.1	EF24	99.35	<i>Nemania bipapillata</i>	Santiago et al. 2018*
	<i>Nemania bipapillata</i>	MN613125	579	MF770848.1	FS123	94.00	<i>Nemania bipapillata</i>	Vandegrift et al. 2017*
	<i>Nemania bipapillata</i>	MN071366	600	MN540693.1	ELFMY15	99.83	<i>Nemania bipapillata</i>	Santiago et al. 2019*
	<i>Nemania bipapillata</i>	MN071369	615	MG881836.1	EF24	99.84	<i>Nemania bipapillata</i>	Santiago et al. 2018*
				GU292818.1	90080610	99.66		Hsieh et al. 2010
	<i>Nemania bipapillata</i>	MN613133	576	MF770848.1	FS123	94.30	<i>Nemania bipapillata</i>	Vandegrift et al. 2017*
	<i>Nemania bipapillata</i>	MW079960	601	JQ341104.1	D2c2a	99.50	<i>Nemania bipapillata</i>	Douanla-Meli et Langer 2012
	<i>Nemania bipapillata</i>	MN613128	616	MG881836.1	EF24	99.84	<i>Nemania bipapillata</i>	Santiago et al. 2018*
	<i>Nemania bipapillata</i>	MN545831	593	JQ341104.1	D2c2a	99.33	<i>Nemania bipapillata</i>	Douanla-Meli et Langer 2012
	<i>Nemania bipapillata</i>	MN545840	598	MF770848.1	FS123	93.96	<i>Nemania bipapillata</i>	Vandegrift et al. 2017*
	<i>Nemania bipapillata</i>	MN545836	618	MG881836.1	EF24	99.19	<i>Nemania bipapillata</i>	Santiago et al. 2018*
	<i>Nemania diffusa</i>	MN545829	594	KY951906.1	MoEF011	99.66	<i>Nemania diffusa</i>	Wang et al. 2018
	<i>Nemania diffusa</i>	MN613126	595	MF770851.1	FS68	99.83	<i>Nemania</i> sp. ‘diffusa var. 1’	Vandegrift et al. 2017*
	<i>Nemania diffusa</i>	MN545837	592	MG881829.1	EF9	99.83	<i>Nemania diffusa</i>	Santiago et al. 2018*
	<i>Nemania diffusa</i>	MN545832	597	MF770851.1	FS68	100	<i>Nemania</i> sp. ‘diffusa var. 1’	Vandegrift et al. 2017*
	<i>Nemania diffusa</i>	MN071363	594	MF770851.1	FS68	99.66	<i>Nemania</i> sp. ‘diffusa var. 1’	Vandegrift et al. 2017*
	<i>Nemania diffusa</i>	MN071365	583	MN341760.1	KoRLI046035	97.03	<i>Nemania diffusa</i>	Oh et al. 2020
	<i>Nemania diffusa</i>	MN613123	589	KY951906.1	MoEF011	99.83	<i>Nemania diffusa</i>	Wang et al. 2018
	<i>Nemania diffusa</i>	MN071364	583	MN540695.1	ELFMY19	99.83	<i>Nemania diffusa</i>	Santiago et al. 2019*
	<i>Nemania diffusa</i>	MN545827	594	KY951906.1	MoEF011	100	<i>Nemania diffusa</i>	Wang et al. 2018
	<i>Nemania diffusa</i>	MW079957	600	MF770851.1	FS68	99.67	<i>Nemania</i> sp. ‘diffusa var. 1’	Vandegrift et al. 2017*
	<i>Nodulisporium</i> sp.	MN153498	589	MN341806.1	KoRLI046261	99.83	<i>Nodulisporium</i> sp.	Oh et al. 2020
				MG832472.1	TS-52	99.65		Pan et al. 2018*
				GQ906963.1	JW89-5	99.65		Li et al. 2009*
	<i>Nodulisporium</i> sp.	MN545833	593	MN341806.1	KoRLI046261	99.66	<i>Nodulisporium</i> sp.	Oh et al. 2020
				MG832472.1	TS-52	99.48		Pan et al. 2018*
				GQ906963.1	JW89-5	99.48		Li et al. 2009*
	<i>Nodulisporium</i> sp.	MW331754	601	MN341806.1	KoRLI04261	96.76	<i>Nodulisporium</i> sp.	Oh et al. 2020
				GQ906963.1	JW89-5	96.92		Li et al. 2009*
	<i>Penicillium</i> sp.	–	597	MT529235.1	EF_586	97.99	<i>Penicillium polonicum</i>	Li 2020*
				MK450672.1	CMV003F3	97.99	<i>Penicillium allii</i>	Visagie et Yilmaz 2019*
	<i>Xylaria apiculata</i>	MN545820	601	MF927538	EF6	98.84	<i>Xylaria apiculata</i>	Poornima et al. 2018
	<i>Xylaria</i> cf. <i>heliscus</i>	MN071355	892	GU324742.1	88113010	98.80	<i>Xylaria</i> cf. <i>heliscus</i>	Hsieh et al. 2010
	<i>Xylaria</i> cf. <i>heliscus</i>	MN071374	911	GU324742.1	88113010	98.36	<i>Xylaria</i> cf. <i>heliscus</i>	Hsieh et al. 2010
	<i>Xylaria</i> cf. <i>heliscus</i>	MW330004	911	GU324742.1	88113010	98.36	<i>Xylaria</i> cf. <i>heliscus</i>	Hsieh et al. 2010

	<i>Xylaria cubensis</i>	MN545821	590	AB625429.1	BCC 18872	99.47	<i>Xylaria cubensis</i>	Okane et al. 2012
	<i>Xylaria cubensis</i>	MN545842	587	AB625429.1	BCC 18872	100	<i>Xylaria cubensis</i>	Okane et al. 2012
	<i>Xylaria feejeensis</i>	MH370737	594	MW081363.1	5-F37	99.30	<i>Xylaria feejeensis</i>	Liu et al. 2020*
	<i>Xylaria feejeensis</i>	MW330002	613	KY951907.1	MoEF032	98.85	<i>Xylaria feejeensis</i>	Wang et al. 2018
	<i>Xylaria intracolorata</i>	MN545839	591	GU324741.1	90080402	99.47	<i>Xylaria intracolorata</i>	Hsieh et al. 2010
	<i>Xylaria laevis</i>	MW330001	605	GU324747	95072910	98.95	<i>Xylaria laevis</i>	Hsieh et al. 2010
	<i>Xylaria</i> sp.	MW331753	604	JQ623492.1	G30	99.31	<i>Xylaria</i> sp.	Buatong et al. 2012*
	<i>Xylaria venustula</i>	MN071370	596	AB625429.1 AB625429.1 AB625412.1	BCC 18872 BCC 1027 BCC 1227	100	<i>Xylaria venustula</i>	Okane et al. 2012
	<i>Xylaria venustula</i>	MN613137	601	MN071385.1	MY21	92.72	<i>Xylaria venustula</i>	Santiago et al. 2019*
	<i>Xylaria venustula</i>	MN613121	591	MN071385.1	MY21	92.80	<i>Xylaria venustula</i>	Santiago et al. 2019*
Lichen host	ELF taxon	GenBank accession number	Length (bp)	Closest GenBank ITS sequence	Culture collection code	Sequencing similarity (%)	Species	Reference
<i>Usnea pectinata</i>	<i>Amphirosellinia fushanensis</i>	MW079958	603	MK247889.1 MT908670.1	G324 Otu0295	99.81	<i>Amphirosellinia fushanensis</i>	Zhang 2018* Zhang 2020*
	<i>Annulohypoxylon albidiscum</i>	MH370738	649	KU852741.1	MFLUCC 15-0645	98.80	<i>Annulohypoxylon albidiscum</i>	Li et al. 2016
	<i>Annulohypoxylon stygium</i>	MH370739	881	FJ848854.1	XH5	99.77	<i>Annulohypoxylon stygium</i>	Wen et al. 2009*
	<i>Annulohypoxylon stygium</i>	MH370740	994	FJ848854.1	XH5	97.70	<i>Annulohypoxylon stygium</i>	Wen et al. 2009*
	<i>Daldinia eschscholtzii</i>	MN071367	593	MH793588.1	AgF4-29-4	99.83	<i>Daldinia eschscholtzii</i>	Lee et Kirschner 2018*
	<i>Digitodochium</i> cf. <i>rhodoleucum</i>	MW329998	632	LC146732.1	NBRC 32296	92.35	<i>Digitodochium rhodoleucum</i>	Ban et al. 2016*
	<i>Kretzschmaria pavimentosa</i>	MW079962	591	MF770841.1	FS75	99.83	<i>Kretzschmaria pavimentosa</i>	Vandegrift et al. 2017*
	<i>Kretzschmaria pavimentosa</i>	MW330000	604	MF770841.1 MN545812.1	FS75 MY93	97.19 97.32	<i>Kretzschmaria pavimentosa</i>	Vandegrift et al. 2017* Santiago et al. 2019*
	<i>Nemania bipapillata</i>	MH370736	584	MF770848.1	FS123	94.38	<i>Nemania bipapillata</i>	Vandegrift et al. 2017*
	<i>Nemania bipapillata</i>	MN545828	616	MG881836	EF24	100	<i>Nemania bipapillata</i>	Santiago et al. 2018*
	<i>Nemania diffusa</i>	MW079963	580	MG881829.1	EF9	100	<i>Nemania diffusa</i>	Santiago et al. 2018*
	<i>Nemania diffusa</i>	MN071359	571	MF770851.1	FS68	100	<i>Nemania</i> sp. ‘diffusa var.1’	Vandegrift et al. 2017*
	<i>Nemania diffusa</i>	MN071356	529	LC505268.1	My-BL71	99.43	<i>Nemania diffusa</i>	Osono et al. 2020
	<i>Nemania diffusa</i>	MH370735	579	KY951906.1	MoEF011	100	<i>Nemania diffusa</i>	Wang et al. 2018
	<i>Nemania diffusa</i>	MN071360	570	MF770851.1	FS68	99.82	<i>Nemania</i> sp. ‘diffusa var.1’	Vandegrift et al. 2017*
	<i>Nemania diffusa</i>	MN071373	597	KY951906.1	MoEF011	99.50	<i>Nemania diffusa</i>	Wang et al. 2018
	<i>Nemania diffusa</i>	MN071371	611	MF770851.1	FS68	99.84	<i>Nemania</i> sp. ‘diffusa var.1’	Vandegrift et al. 2017*
	<i>Nemania diffusa</i>	MN613136	590	MF770849.1	FS112	97.64	<i>Nemania</i> sp. ‘diffusa var. 1’	Vandegrift et al. 2017*
	<i>Nemania diffusa</i>	MN545817	586	KY951906.1	MoEF011	100	<i>Nemania diffusa</i>	Wang et al. 2018
	<i>Nemania diffusa</i>	MN545835	592	MF770851.1	FS68	99.83	<i>Nemania</i> sp. ‘diffusa var. 1’	Vandegrift et al. 2017*
	<i>Nemania diffusa</i>	MN613132	594	MN613114.1	MY64	99.50	<i>Nemania diffusa</i>	Santiago et al. 2019*
	<i>Nemania primolutea</i>	MW329999	604	EF026121.1	91102001	97.39	<i>Nemania primolutea</i>	Hsieh et al. 2010
	<i>Nemania primolutea</i>	MN613130	597	EF026121.1	91102001	97.55	<i>Nemania primolutea</i>	Hsieh et al. 2010
	<i>Nodulisporium</i> sp.	MN071358	525	MN341806.1	KoRLI046261	100	<i>Nodulisporium</i> sp.	Oh et al. 2020
	<i>Xylaria curta</i>	MN613122	622	KJ883611.1	100	98.39	<i>Xylaria curta</i>	Serrato-Diaz et al. 2014*
	<i>Xylaria venustula</i>	MN071361	615	GU300091.1 KJ572202.1	88113002 YN31	99.66 99.83	<i>Xylaria venustula</i>	Hsieh et al. 2010 Min 2014*

* References not found, probably unpublished sequences; name and year indicate submission of the sequence in GenBank.

References

- Alwahshi K.J., Saeed E.E., Sham A., Alblooshi A.A., Alblooshi M.M., El-Tarabily K.A., AbuQamar S.F. (2019): Molecular identification and disease management of date palm sudden decline syndrome in the United Arab Emirates. – Int. J. Mol. Sci. 20: 923. DOI: <https://doi.org/10.3390/ijms20040923>
- Chow Y.Y., Ting A.S.Y. (2015): Endophytic l-asparaginase-producing fungi from plants associated with anticancer properties. – J. Adv. Res. 6: 869–876. DOI: <https://doi.org/10.1016/j.jare.2014.07.005>
- Douanla-Meli C., Langer E. (2012): Diversity and molecular phylogeny of fungal endophytes associated with *Diospyros crassiflora*. – Mycology 3: 175–187.
- Hsieh H.M., Lin C.R., Fang M.J., Rogers J.D., Fournier J., Lechat C., Ju Y.M. (2010): Phylogenetic status of *Xylaria* subgenus *Pseudoxylaria* among taxa of the subfamily *Xylarioideae* (*Xylariaceae*) and phylogeny of the taxa involved in the subfamily. – Mol. Phylogenet. Evol. 54: 957–969. DOI: <https://doi.org/10.1016/j.ympev.2009.12.015>
- Li G.J. et al. (2016): Fungal diversity notes 253–366: taxonomic and phylogenetic contributions to fungal taxa. – Fungal Divers. 78: 1–237. DOI: <https://doi.org/10.1007/s13225-016-0366-9>
- Oh S.-Y., Yang J.H., Woo J.-J., Oh S.-O., Hur J.-S. (2020): Diversity and distribution patterns of endolichenic fungi in Jeju Island, South Korea. – Sustainability 12: 3769. DOI: <https://doi.org/10.3390/su12093769>
- Okane I., Srikitikulchai P., Tabuchi Y., Sivichai S., Nakagiri A. (2012): Recognition and characterization of four Thai xylariaceous fungi inhabiting various tropical foliages as endophytes by DNA sequences and host plant preference. – Mycoscience 53: 122–132. DOI: <https://doi.org/10.1007/S10267-011-0149-9>
- Osono T., Matsuoka S., Hirose D. (2020): Diversity and geographic distribution of lignolytic fungi associated with *Castanopsis sieboldii* leaf litter in Japan. – Front. Microbiol. 11: 595427. DOI: <https://doi.org/10.3389/fmicb.2020.595427>.
- Poornima S., Ponmurugan P., Gnanamangai B.M., Gayathri G., Dheenadhayalan K., Ayyappadasan G. (2018): Screening of biologically potent endolichenic fungi isolated from selected lichens habitat on silver oak tree. – Vegetos 31: 89–94. DOI: <https://doi.org/10.5958/2229-4473.2018.00078.2>
- Sir E.B., Kuhnert E., Surup F., Hyde K.D., Stadler M. (2015): Discovery of new mitorubrin derivatives from *Hypoxylon fulvo-sulphureum* sp. nov. (*Ascomycota*, *Xylariales*). – Mycol. Prog. 14: 28. DOI: <https://doi.org/10.1007/s11557-015-1043-1>
- Wang Y., Wang J., Wang S.-H., Li Y.-Q., Yuan X.-L., Chen Z.-H. (2018): Diversity of endophytic fungi of *Malania oleifera* Chun et Lee. – Gen. Appl. Biol. 37: 3859–3866.