**Supplementary Materials**

**Linkages and key factors between soil bacterial and fungal communities along an altitudinal gradient on Mount Segrila, Tibet, China**

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Supporting Information Includes:

- 4 tables

- 1 figure

**Table S1.** Soil physical properties of mechanical composition at different sites from varying altitudes on Mount Segrila.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Clay** | **Slit** | **Fine sand** | **Coarse sand** | **Sand** |
| **N1** | 15.55% | 16.84% | 41.61% | 25.79% | 67.61% |
| **N2** | 15.19% | 20.63% | 48.18% | 15.79% | 64.18% |
| **N3** | 12.39% | 27.52% | 42.09% | 17.77% | 60.09% |
| **N4** | 18.93% | 21.44% | 31.63% | 28.28% | 59.63% |
| **N5** | 12.38% | 23.91% | 46.71% | 16.92% | 63.71% |
| **P1** | 8.58% | 25.75% | 38.67% | 27.42% | 65.67% |
| **P2** | 13.86% | 23.30% | 57.84% | 4.55% | 62.84% |
| **P3** | 11.37% | 17.56% | 27.07% | 44.39% | 71.07% |
| **P4** | 12.73% | 21.21% | 49.06% | 15.54% | 65.06% |
| **P5** | 15.87% | 22.13% | 50.00% | 12.11% | 62.00% |

P and N represent east slope and west slope, respectively. Different numbers mean different elevations (Number 1, 2, 3, 4, and 5 represent 4300 m, 4100 m, 3900 m, 3700 m, and 3500 m, respectively).



**Figure S1.** The variation of microbial community composition of soil samples across the elevational gradient on Mount Segrila. Principal co-ordinates analysis (PCoA) based on the bacterial (A) and signification difference comparison between different group of (B) bacterial community (OTU level). P and N represent east slope and west slope, respectively. A represents altitudes. Different numbers mean different elevations (Number 1, 2, 3, 4, and 5 represent 4300 m, 4100 m, 3900 m, 3700 m, and 3500 m, respectively).

|  |
| --- |
| **Table S2(a). Neighbors of core microbes in fungal-bacterial co-occurrence network in 3700, 3900, 4100 m** |

|  |  |
| --- | --- |
| **Key Species** | **Neighbors** |

|  |  |
| --- | --- |
| ***Clavaria* sp** |  |
|  | *unclassified\_o\_\_Agaricales* |
|  | *Pleotrichocladium\_opacum* |
|  | *unclassified\_o\_\_Helotiales* |
|  | *Sebacina\_sp* |
|  | *Archaeorhizomycetes\_sp* |
|  | *Goffeauzyma\_gastrica* |
|  | *Pezoloma\_ericae* |
|  | *unclassified\_g\_\_norank\_f\_\_Xanthobacteraceae* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Acidobacteriales* |
|  | *unclassified\_g\_\_Candidatus\_Solibacter* |
|  | *uncultured\_bacterium\_g\_\_Pseudonocardia* |
|  | *unclassified\_f\_\_Comamonadaceae* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_AD3* |
|  | *unclassified\_g\_\_norank\_f\_\_Micropepsaceae* |
|  | *metagenome\_g\_\_Gaiella* |
|  | *unclassified\_c\_\_Alphaproteobacteria* |
|  | *uncultured\_bacterium\_g\_\_Granulicella* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_norank\_p\_\_WPS-2* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Subgroup\_2* |
|  | *unclassified\_g\_\_norank\_f\_\_norank\_o\_\_Elsterales* |
|  | *uncultured\_Acidobacteriaceae\_bacterium\_g\_\_norank\_f\_\_norank* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_A21b* |
|  | *unclassified\_g\_\_norank\_f\_\_Amb-16S-1323* |
|  | *unclassified\_g\_\_Bacillus* |
|  | *unclassified\_g\_\_Bryobacter* |
|  | *unclassified\_g\_\_HSB\_OF53-F07* |
| ***Clavaria falcata*** |  |
|  | *Mortierella\_horticola* |
|  | *Pleotrichocladium\_opacum* |
|  | *Amphinema\_sp* |
|  | *Sebacina\_sp* |
|  | *Goffeauzyma\_gastrica* |
|  | *Tomentella\_stuposa* |
|  | *unclassified\_g\_\_norank\_f\_\_Xanthobacteraceae* |
|  | *uncultured\_Acidimicrobiales\_bacterium\_g\_\_norank\_f\_\_norank* |
|  | *unclassified\_g\_\_Gemmatimonas* |
|  | *unclassified\_f\_\_Comamonadaceae* |
|  | *unclassified\_g\_\_norank\_f\_\_Vicinamibacteraceae* |
|  | *unclassified\_g\_\_norank\_f\_\_Micropepsaceae* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_KD4-96* |
|  | *uncultured\_bacterium\_g\_\_Galbitalea* |
|  | *metagenome\_g\_\_Gaiella* |
|  | *unclassified\_c\_\_Alphaproteobacteria* |
|  | *unclassified\_c\_\_Actinobacteria* |
|  | *unclassified\_g\_\_norank\_f\_\_Acetobacteraceae* |
|  | *unclassified\_o\_\_Frankiales* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Vicinamibacterales* |
|  | *unclassified\_g\_\_norank\_f\_\_norank\_o\_\_Elsterales* |
|  | *uncultured\_Bellilinea\_sp.\_g\_\_norank\_f\_\_Anaerolineaceae* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_A21b* |
|  | *unclassified\_g\_\_norank\_f\_\_Amb-16S-1323* |
|  | *unclassified\_g\_\_Nakamurella* |
|  | *unclassified\_g\_\_Bryobacter* |
|  | *unclassified\_g\_\_HSB\_OF53-F07* |
|  | *metagenome\_g\_\_norank\_f\_\_67-14* |
|  | *Nocardioides\_sp.\_g\_\_Nocardioides* |
| ***Saitozyma* sp** |  |
|  | *Mortierella\_humilis* |
|  | *Russula\_cyanoxantha* |
|  | *Russula\_puellaris* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Elsterales* |
|  | *unclassified\_g\_\_mle1-7* |
|  | *unclassified\_o\_\_Burkholderiales* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_MB-A2-108* |
|  | *unclassified\_g\_\_norank\_f\_\_norank\_o\_\_Subgroup\_17* |
|  | *unclassified\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_Acidimicrobiia* |
|  | *unclassified\_g\_\_Acidothermus* |
|  | *metagenome\_g\_\_Reyranella* |
|  | *metagenome\_g\_\_norank\_f\_\_Micropepsaceae* |
|  | *unclassified\_g\_\_Candidatus\_Udaeobacter* |
|  | *uncultured\_Acidobacteria\_bacterium\_g\_\_Acidipila* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Rokubacteriales* |
|  | *uncultured\_Chloroflexi\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_KD4-96* |
|  | *unclassified\_o\_\_Saccharimonadales* |
|  | *uncultured\_bacterium\_g\_\_IS-44* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Subgroup\_7* |
|  | *uncultured\_bacterium\_g\_\_Geobacter* |
|  | *unclassified\_g\_\_Pedomicrobium* |
|  | *unclassified\_g\_\_Occallatibacter* |
| ***Mortierella humilis*** |  |
|  | *unclassified\_c\_\_Eurotiomycetes* |
|  | *metagenome\_g\_\_norank\_f\_\_norank\_o\_\_Gaiellales* |
|  | *uncultured\_forest\_soil\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Subgroup\_2* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Elsterales* |
|  | *unclassified\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_KD4-96* |
|  | *uncultured\_actinobacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_MB-A2-108* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_MB-A2-108* |
|  | *unclassified\_g\_\_norank\_f\_\_norank\_o\_\_Subgroup\_17* |
|  | *uncultured\_bacterium\_g\_\_Roseiarcus* |
|  | *unclassified\_g\_\_Arthrobacter* |
|  | *unclassified\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_Acidimicrobiia* |
|  | *unclassified\_g\_\_Acidothermus* |
|  | *metagenome\_g\_\_Reyranella* |
|  | *unclassified\_g\_\_Candidatus\_Udaeobacter* |
|  | *uncultured\_forest\_soil\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Acidobacteriales* |
|  | *unclassified\_g\_\_Candidatus\_Xiphinematobacter* |
|  | *uncultured\_Acidobacteria\_bacterium\_g\_\_Acidipila* |
|  | *unclassified\_g\_\_norank\_f\_\_Gemmataceae* |
|  | *uncultured\_forest\_soil\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_Acidimicrobiia* |
|  | *uncultured\_Acidobacteria\_bacterium\_g\_\_Occallatibacter* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Rokubacteriales* |
|  | *unclassified\_g\_\_Hyphomicrobium* |
|  | *metagenome\_g\_\_norank\_f\_\_TRA3-20* |
|  | *uncultured\_bacterium\_g\_\_Oryzihumus* |
|  | *uncultured\_bacterium\_g\_\_IS-44* |
|  | *unclassified\_g\_\_Conexibacter* |
|  | *unclassified\_g\_\_norank\_f\_\_norank\_o\_\_Vicinamibacterales* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Subgroup\_7* |
|  | *uncultured\_Gemmatimonadales\_bacterium\_g\_\_norank\_f\_\_Gemmatimonadaceae* |
|  | *metagenome\_g\_\_norank\_f\_\_Acetobacteraceae* |
|  | *uncultured\_bacterium\_g\_\_Geobacter* |
|  | *metagenome\_g\_\_norank\_f\_\_Methyloligellaceae* |
|  | *unclassified\_g\_\_Pedomicrobium* |
|  | *uncultured\_bacterium\_g\_\_Acidothermus* |
| ***Goffeauzyma gastrica*** |  |
|  | *Tomentella\_stuposa* |
|  | *unclassified\_g\_\_norank\_f\_\_Xanthobacteraceae* |
|  | *uncultured\_Acidimicrobiales\_bacterium\_g\_\_norank\_f\_\_norank* |
|  | *unclassified\_g\_\_norank\_f\_\_norank\_o\_\_Subgroup\_7* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Acidobacteriales* |
|  | *unclassified\_g\_\_Candidatus\_Solibacter* |
|  | *uncultured\_bacterium\_g\_\_Pseudonocardia* |
|  | *unclassified\_g\_\_Gemmatimonas* |
|  | *Clostridium\_estertheticum* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_AD3* |
|  | *unclassified\_g\_\_norank\_f\_\_Micropepsaceae* |
|  | *unclassified\_g\_\_Mycobacterium* |
|  | *unclassified\_c\_\_Alphaproteobacteria* |
|  | *unclassified\_g\_\_Iamia* |
|  | *unclassified\_g\_\_norank\_f\_\_Acetobacteraceae* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Subgroup\_2* |
|  | *uncultured\_Acidobacteriaceae\_bacterium\_g\_\_norank\_f\_\_norank* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_A21b* |
|  | *unclassified\_g\_\_norank\_f\_\_Amb-16S-1323* |
|  | *unclassified\_g\_\_Nakamurella* |
|  | *unclassified\_g\_\_RB41* |
|  | *metagenome\_g\_\_norank\_f\_\_67-14* |
|  | *Nocardioides\_sp.\_g\_\_Nocardioides* |
|  | *Pleotrichocladium\_opacum* |
| ***Sebacina* sp** |  |
|  | *Archaeorhizomycetes\_sp* |
|  | *unclassified\_f\_\_Mortierellaceae* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Gaiellales* |
|  | *uncultured\_Acidimicrobiales\_bacterium\_g\_\_norank\_f\_\_norank* |
|  | *uncultured\_Chloroflexi\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_AD3* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Acidobacteriales* |
|  | *unclassified\_g\_\_Candidatus\_Solibacter* |
|  | *uncultured\_bacterium\_g\_\_Pseudonocardia* |
|  | *unclassified\_g\_\_Gemmatimonas* |
|  | *unclassified\_f\_\_Comamonadaceae* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_AD3* |
|  | *metagenome\_g\_\_Gaiella* |
|  | *unclassified\_g\_\_norank\_f\_\_Acetobacteraceae* |
|  | *uncultured\_Acidobacteria\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Subgroup\_2* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Subgroup\_2* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_JG36-TzT-191* |
|  | *unclassified\_g\_\_norank\_f\_\_norank\_o\_\_Elsterales* |
|  | *uncultured\_Acidobacteriaceae\_bacterium\_g\_\_norank\_f\_\_norank* |
|  | *unclassified\_g\_\_norank\_f\_\_SC-I-84* |
|  | *unclassified\_g\_\_Nakamurella* |
|  | *uncultured\_Acidobacteria\_bacterium\_g\_\_Bryobacter* |
|  | *uncultured\_bacterium\_g\_\_Aquisphaera* |
|  | *unclassified\_g\_\_Bryobacter* |
|  | *unclassified\_g\_\_HSB\_OF53-F07* |
|  | *metagenome\_g\_\_norank\_f\_\_67-14* |
|  | *Nocardioides\_sp.\_g\_\_Nocardioides* |
|  | *Sebacina\_sp* |
| ***Pleotrichocladium opacum*** |
|  | *Archaeorhizomycetes\_sp* |
|  | *unclassified\_f\_\_Mortierellaceae* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Gaiellales* |
|  | *uncultured\_Acidimicrobiales\_bacterium\_g\_\_norank\_f\_\_norank* |
|  | *uncultured\_Chloroflexi\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_AD3* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Acidobacteriales* |
|  | *unclassified\_g\_\_Candidatus\_Solibacter* |
|  | *uncultured\_bacterium\_g\_\_Pseudonocardia* |
|  | *unclassified\_g\_\_Gemmatimonas* |
|  | *unclassified\_f\_\_Comamonadaceae* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_AD3* |
|  | *metagenome\_g\_\_Gaiella* |
|  | *unclassified\_g\_\_norank\_f\_\_Acetobacteraceae* |
|  | *uncultured\_Acidobacteria\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Subgroup\_2* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Subgroup\_2* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_JG36-TzT-191* |
|  | *unclassified\_g\_\_norank\_f\_\_norank\_o\_\_Elsterales* |
|  | *uncultured\_Acidobacteriaceae\_bacterium\_g\_\_norank\_f\_\_norank* |
|  | *unclassified\_g\_\_norank\_f\_\_SC-I-84* |
|  | *unclassified\_g\_\_Nakamurella* |
|  | *uncultured\_Acidobacteria\_bacterium\_g\_\_Bryobacter* |
|  | *uncultured\_bacterium\_g\_\_Aquisphaera* |
|  | *unclassified\_g\_\_Bryobacter* |
|  | *unclassified\_g\_\_HSB\_OF53-F07* |
|  | *metagenome\_g\_\_norank\_f\_\_67-14* |

**Table S2(b). Neighbors of core microbes in fungal-bacterial co-occurrence network in 3500, 4300 m**

|  |  |
| --- | --- |
| **Key Species** | **Neighbors** |
| ***Clavaria* sp** | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Acidobacteriales* |
|  | *unclassified\_g\_\_Candidatus\_Solibacter* |
|  | *uncultured\_bacterium\_g\_\_Pseudonocardia* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_AD3* |
|  | *unclassified\_o\_\_Acidobacteriales* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Subgroup\_2* |
|  | *uncultured\_Acidobacteriaceae\_bacterium\_g\_\_norank\_f\_\_norank* |
|  |  |
| ***Clavaria falcata*** |  |
|  | *unclassified\_f\_\_Micromonosporaceae* |
|  | *bacterium\_Ellin6089* |
|  | *unclassified\_g\_\_Gemmatimonas* |
|  | *unclassified\_g\_\_norank\_f\_\_Acetobacteraceae* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_Ilumatobacteraceae* |
|  | *unclassified\_g\_\_Nakamurella* |
|  | *metagenome\_g\_\_norank\_f\_\_67-14* |
|  | *Nocardioides\_sp.\_g\_\_Nocardioides* |
| ***Saitozyma* sp** |  |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Elsterales* |
|  | *unclassified\_g\_\_norank\_f\_\_A0839* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_MB-A2-108* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Rokubacteriales* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Subgroup\_7* |
|  | *unclassified\_g\_\_GOUTA6* |
|  | *uncultured\_bacterium\_g\_\_Geobacter* |
|  | *unclassified\_g\_\_Pedomicrobium* |
| ***Goffeauzyma gastrica*** |  |
|  | *unclassified\_g\_\_norank\_f\_\_Xanthobacteraceae* |
|  | *uncultured\_gamma\_proteobacterium\_g\_\_Acidibacter* |
|  | *unclassified\_g\_\_norank\_f\_\_Micropepsaceae* |
|  | *unclassified\_c\_\_Alphaproteobacteria* |
|  | *uncultured\_bacterium\_g\_\_norank\_f\_\_A21b* |
|  | *unclassified\_g\_\_norank\_f\_\_Amb-16S-1323* |
| ***Pleotrichocladium opacum*** |
|  | *unclassified\_f\_\_Comamonadaceae* |
|  | *metagenome\_g\_\_Gaiella* |
|  | *unclassified\_g\_\_norank\_f\_\_norank\_o\_\_Elsterales* |
|  | *uncultured\_bacterium\_g\_\_Luedemannella* |
|  | *unclassified\_g\_\_Bryobacter* |
|  | *unclassified\_g\_\_HSB\_OF53-F07* |
|  | *Ilyonectria\_rufa* |
|  | *Sebacina\_sp* |
| ***Mortierella humilis*** |  |
|  | *unclassified\_g\_\_norank\_f\_\_Gemmatimonadaceae* |
|  | *unclassified\_g\_\_norank\_f\_\_norank\_o\_\_Subgroup\_17* |
|  | *unclassified\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_Acidimicrobiia* |
|  | *unclassified\_g\_\_Acidothermus* |
|  | *metagenome\_g\_\_Reyranella* |
|  | *unclassified\_g\_\_Candidatus\_Udaeobacter* |
|  | *uncultured\_planctomycete\_g\_\_norank\_f\_\_Gemmataceae* |
|  | *uncultured\_Acidobacteria\_bacterium\_g\_\_Acidipila* |
|  | *uncultured\_bacterium\_g\_\_IS-44* |
|  | *uncultured\_beta\_proteobacterium\_g\_\_norank\_f\_\_SC-I-84* |
| ***Sebacina* sp** |  |
|  | *unclassified\_f\_\_Comamonadaceae* |
|  | *metagenome\_g\_\_Gaiella* |
|  | *unclassified\_g\_\_norank\_f\_\_norank\_o\_\_Elsterales* |
|  | *uncultured\_bacterium\_g\_\_Luedemannella* |
|  | *unclassified\_g\_\_Bryobacter* |
|  | *unclassified\_g\_\_HSB\_OF53-F07* |
|  | *Ilyonectria\_rufa* |
|  | *Pleotrichocladium\_opacum* |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Species****Table S3. Information of different speices connect to core microbes in different altitudes** | **Phylum** | **Class** | **Order** | **Family** | **Genus** |
| **3700, 3900,4100 m**  |
| *unclassified\_o\_\_Agaricales* | Basidiomycota | Agaricomycetes | Agaricales | unclassified\_o\_\_Agaricales | *unclassified\_o\_\_Agaricales* |
| *unclassified\_o\_\_Helotiales* | Ascomycota | Leotiomycetes | Helotiales | unclassified\_o\_\_Helotiales | *unclassified\_o\_\_Helotiales* |
| *Archaeorhizomycetes\_sp* | Ascomycota | Archaeorhizomycetes | unclassified\_c\_\_Archaeorhizomycetes | unclassified\_c\_\_Archaeorhizomycetes | *unclassified\_c\_\_Archaeorhizomycetes* |
| *Pezoloma\_ericae* | Ascomycota | Leotiomycetes | Helotiales | Leotiaceae | *Pezoloma* |
| *uncultured\_bacterium\_g\_\_Granulicella* | Acidobacteriota | Acidobacteriae | Acidobacteriales | Acidobacteriaceae\_Subgroup\_1 | *Granulicella* |
| *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_norank\_p\_\_WPS-2* | WPS-2 | norank\_p\_\_WPS-2 | norank\_c\_\_norank\_p\_\_WPS-2 | norank\_o\_\_norank\_c\_\_norank\_p\_\_WPS-2 | *norank\_f\_\_norank\_o\_\_norank\_c\_\_norank\_p\_\_WPS-2* |
| *unclassified\_g\_\_Bacillus* | Firmicutes | Bacilli | Bacillales | Bacillaceae | *Bacillus* |
| *Mortierella\_horticola* | Mortierellomycota | Mortierellomycetes | Mortierellales | Mortierellaceae | *Mortierella* |
| *Amphinema\_sp* | Basidiomycota | Agaricomycetes | Atheliales | Atheliaceae | *Amphinema* |
| *Tomentella\_stuposa* | Basidiomycota | Agaricomycetes | Thelephorales | Thelephoraceae | *Tomentella* |
| *uncultured\_Acidimicrobiales\_bacterium\_g\_\_norank\_f\_\_norank* | Actinobacteriota | Acidimicrobiia | IMCC26256 | norank\_o\_\_IMCC26256 | *norank\_f\_\_norank\_o\_\_IMCC26256* |
| *unclassified\_g\_\_norank\_f\_\_Vicinamibacteraceae* | Acidobacteriota | Vicinamibacteria | Vicinamibacterales | Vicinamibacteraceae | *norank\_f\_\_Vicinamibacteraceae* |
| *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_KD4-96* | Chloroflexi | KD4-96 | norank\_c\_\_KD4-96 | norank\_o\_\_norank\_c\_\_KD4-96 | *norank\_f\_\_norank\_o\_\_norank\_c\_\_KD4-96* |
| *uncultured\_bacterium\_g\_\_Galbitalea* | Actinobacteriota | Actinobacteria | Micrococcales | Microbacteriaceae | *Galbitalea* |
| *unclassified\_c\_\_Actinobacteria* | Actinobacteriota | Actinobacteria | unclassified\_c\_\_Actinobacteria | unclassified\_c\_\_Actinobacteria | *unclassified\_c\_\_Actinobacteria* |
| *unclassified\_o\_\_Frankiales* | Actinobacteriota | Actinobacteria | Frankiales | unclassified\_o\_\_Frankiales | *unclassified\_o\_\_Frankiales* |
| *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Vicinamibacterales* | Acidobacteriota | Vicinamibacteria | Vicinamibacterales | norank\_o\_\_Vicinamibacterales | *norank\_f\_\_norank\_o\_\_Vicinamibacterales* |
| *uncultured\_Bellilinea\_sp.\_g\_\_norank\_f\_\_Anaerolineaceae* | Chloroflexi | Anaerolineae | Anaerolineales | Anaerolineaceae | *norank\_f\_\_Anaerolineaceae* |
| *Russula\_cyanoxantha* | Basidiomycota | Agaricomycetes | Russulales | Russulaceae | *Russula* |
| *Russula\_puellaris* | Basidiomycota | Agaricomycetes | Russulales | Russulaceae | *Russula* |
| *unclassified\_g\_\_mle1-7* | Proteobacteria | Gammaproteobacteria | Burkholderiales | Nitrosomonadaceae | *mle1-7* |
| *unclassified\_o\_\_Burkholderiales* | Proteobacteria | Gammaproteobacteria | Burkholderiales | unclassified\_o\_\_Burkholderiales | *unclassified\_o\_\_Burkholderiales* |
| *metagenome\_g\_\_norank\_f\_\_Micropepsaceae* | Proteobacteria | Alphaproteobacteria | Micropepsales | Micropepsaceae | *norank\_f\_\_Micropepsaceae* |
| *uncultured\_Chloroflexi\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_KD4-96* | Chloroflexi | KD4-96 | norank\_c\_\_KD4-96 | norank\_o\_\_norank\_c\_\_KD4-96 | *norank\_f\_\_norank\_o\_\_norank\_c\_\_KD4-96* |
| *unclassified\_o\_\_Saccharimonadales* | Patescibacteria | Saccharimonadia | Saccharimonadales | unclassified\_o\_\_Saccharimonadales | *unclassified\_o\_\_Saccharimonadales* |
| *unclassified\_g\_\_Occallatibacter* | Acidobacteriota | Acidobacteriae | Acidobacteriales | Acidobacteriaceae\_Subgroup\_1 | *Occallatibacter* |
| *unclassified\_c\_\_Eurotiomycetes* | Ascomycota | Eurotiomycetes | unclassified\_c\_\_Eurotiomycetes | unclassified\_c\_\_Eurotiomycetes | *unclassified\_c\_\_Eurotiomycetes* |
| *metagenome\_g\_\_norank\_f\_\_norank\_o\_\_Gaiellales* | Actinobacteriota | Thermoleophilia | Gaiellales | norank\_o\_\_Gaiellales | *norank\_f\_\_norank\_o\_\_Gaiellales* |
| *uncultured\_forest\_soil\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Subgroup\_2* | Acidobacteriota | Acidobacteriae | Subgroup\_2 | norank\_o\_\_Subgroup\_2 | *norank\_f\_\_norank\_o\_\_Subgroup\_2* |
| *unclassified\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_KD4-96* | Chloroflexi | KD4-96 | norank\_c\_\_KD4-96 | norank\_o\_\_norank\_c\_\_KD4-96 | *norank\_f\_\_norank\_o\_\_norank\_c\_\_KD4-96* |
| *uncultured\_actinobacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_MB-A2-108* | Actinobacteriota | MB-A2-108 | norank\_c\_\_MB-A2-108 | norank\_o\_\_norank\_c\_\_MB-A2-108 | *norank\_f\_\_norank\_o\_\_norank\_c\_\_MB-A2-108* |
| *uncultured\_bacterium\_g\_\_Roseiarcus* | Proteobacteria | Alphaproteobacteria | Rhizobiales | Beijerinckiaceae | *Roseiarcus* |
| *unclassified\_g\_\_Arthrobacter* | Actinobacteriota | Actinobacteria | Micrococcales | Micrococcaceae | *Arthrobacter* |
| *uncultured\_forest\_soil\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Acidobacteriales* | Acidobacteriota | Acidobacteriae | Acidobacteriales | norank\_o\_\_Acidobacteriales | *norank\_f\_\_norank\_o\_\_Acidobacteriales* |
| *unclassified\_g\_\_Candidatus\_Xiphinematobacter* | Verrucomicrobiota | Verrucomicrobiae | Chthoniobacterales | Xiphinematobacteraceae | *Candidatus\_Xiphinematobacter* |
| *unclassified\_g\_\_norank\_f\_\_Gemmataceae* | Planctomycetota | Planctomycetes | Gemmatales | Gemmataceae | *norank\_f\_\_Gemmataceae* |
| *uncultured\_forest\_soil\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_Acidimicrobiia* | Actinobacteriota | Acidimicrobiia | norank\_c\_\_Acidimicrobiia | norank\_o\_\_norank\_c\_\_Acidimicrobiia | *norank\_f\_\_norank\_o\_\_norank\_c\_\_Acidimicrobiia* |
| *uncultured\_Acidobacteria\_bacterium\_g\_\_Occallatibacter* | Acidobacteriota | Acidobacteriae | Acidobacteriales | Acidobacteriaceae\_Subgroup\_1 | *Occallatibacter* |
| *unclassified\_g\_\_Hyphomicrobium* | Proteobacteria | Alphaproteobacteria | Rhizobiales | Hyphomicrobiaceae | *Hyphomicrobium* |
| *metagenome\_g\_\_norank\_f\_\_TRA3-20* | Proteobacteria | Gammaproteobacteria | Burkholderiales | TRA3-20 | *norank\_f\_\_TRA3-20* |
| *uncultured\_bacterium\_g\_\_Oryzihumus* | Actinobacteriota | Actinobacteria | Micrococcales | Intrasporangiaceae | *Oryzihumus* |
| *unclassified\_g\_\_Conexibacter* | Actinobacteriota | Thermoleophilia | Solirubrobacterales | Solirubrobacteraceae | *Conexibacter* |
| *unclassified\_g\_\_norank\_f\_\_norank\_o\_\_Vicinamibacterales* | Acidobacteriota | Vicinamibacteria | Vicinamibacterales | norank\_o\_\_Vicinamibacterales | *norank\_f\_\_norank\_o\_\_Vicinamibacterales* |
| *uncultured\_Gemmatimonadales\_bacterium\_g\_\_norank\_f\_\_Gemmatimonadaceae* | Gemmatimonadota | Gemmatimonadetes | Gemmatimonadales | Gemmatimonadaceae | *norank\_f\_\_Gemmatimonadaceae* |
| *metagenome\_g\_\_norank\_f\_\_Acetobacteraceae* | Proteobacteria | Alphaproteobacteria | Acetobacterales | Acetobacteraceae | *norank\_f\_\_Acetobacteraceae* |
| *metagenome\_g\_\_norank\_f\_\_Methyloligellaceae* | Proteobacteria | Alphaproteobacteria | Rhizobiales | Methyloligellaceae | *norank\_f\_\_Methyloligellaceae* |
| *uncultured\_bacterium\_g\_\_Acidothermus* | Actinobacteriota | Actinobacteria | Frankiales | Acidothermaceae | *Acidothermus* |
| *Tomentella\_stuposa* | Basidiomycota | Agaricomycetes | Thelephorales | Thelephoraceae | *Tomentella* |
| *uncultured\_Acidimicrobiales\_bacterium\_g\_\_norank\_f\_\_norank* | Actinobacteriota | Acidimicrobiia | IMCC26256 | norank\_o\_\_IMCC26256 | *norank\_f\_\_norank\_o\_\_IMCC26256* |
| *unclassified\_g\_\_norank\_f\_\_norank\_o\_\_Subgroup\_7* | Acidobacteriota | Holophagae | Subgroup\_7 | norank\_o\_\_Subgroup\_7 | *norank\_f\_\_norank\_o\_\_Subgroup\_7* |
| *Clostridium\_estertheticum* | Firmicutes | Clostridia | Clostridiales | Clostridiaceae | *Clostridium\_sensu\_stricto\_13* |
| *unclassified\_g\_\_Mycobacterium* | Actinobacteriota | Actinobacteria | Corynebacteriales | Mycobacteriaceae | *Mycobacterium* |
| *unclassified\_g\_\_Iamia* | Actinobacteriota | Acidimicrobiia | Microtrichales | Iamiaceae | *Iamia* |
| *unclassified\_g\_\_RB41* | Acidobacteriota | Blastocatellia | Pyrinomonadales | Pyrinomonadaceae | *RB41* |
| *Archaeorhizomycetes\_sp* | Ascomycota | Archaeorhizomycetes | unclassified\_c\_\_Archaeorhizomycetes | unclassified\_c\_\_Archaeorhizomycetes | *unclassified\_c\_\_Archaeorhizomycetes* |
| *unclassified\_f\_\_Mortierellaceae* | Mortierellomycota | Mortierellomycetes | Mortierellales | Mortierellaceae | *unclassified\_f\_\_Mortierellaceae* |
| *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Gaiellales* | Actinobacteriota | Thermoleophilia | Gaiellales | norank\_o\_\_Gaiellales | *norank\_f\_\_norank\_o\_\_Gaiellales* |
| *uncultured\_Acidimicrobiales\_bacterium\_g\_\_norank\_f\_\_norank* | Actinobacteriota | Acidimicrobiia | IMCC26256 | norank\_o\_\_IMCC26256 | *norank\_f\_\_norank\_o\_\_IMCC26256* |
| *uncultured\_Chloroflexi\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_AD3* | Chloroflexi | AD3 | norank\_c\_\_AD3 | norank\_o\_\_norank\_c\_\_AD3 | *norank\_f\_\_norank\_o\_\_norank\_c\_\_AD3* |
| *uncultured\_Acidobacteria\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Subgroup\_2* | Acidobacteriota | Acidobacteriae | Subgroup\_2 | norank\_o\_\_Subgroup\_2 | *norank\_f\_\_norank\_o\_\_Subgroup\_2* |
| *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_JG36-TzT-191* | Proteobacteria | Gammaproteobacteria | JG36-TzT-191 | norank\_o\_\_JG36-TzT-191 | *norank\_f\_\_norank\_o\_\_JG36-TzT-191* |
| *unclassified\_g\_\_norank\_f\_\_SC-I-84* | Proteobacteria | Gammaproteobacteria | Burkholderiales | SC-I-84 | *norank\_f\_\_SC-I-84* |
| *uncultured\_Acidobacteria\_bacterium\_g\_\_Bryobacter* | Acidobacteriota | Acidobacteriae | Bryobacterales | Bryobacteraceae | *Bryobacter* |
| *uncultured\_bacterium\_g\_\_Aquisphaera* | Planctomycetota | Planctomycetes | Isosphaerales | Isosphaeraceae | *Aquisphaera* |
| *Archaeorhizomycetes\_sp* | Ascomycota | Archaeorhizomycetes | unclassified\_c\_\_Archaeorhizomycetes | unclassified\_c\_\_Archaeorhizomycetes | *unclassified\_c\_\_Archaeorhizomycetes* |
| *unclassified\_f\_\_Mortierellaceae* | Mortierellomycota | Mortierellomycetes | Mortierellales | Mortierellaceae | *unclassified\_f\_\_Mortierellaceae* |
| *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Gaiellales* | Actinobacteriota | Thermoleophilia | Gaiellales | norank\_o\_\_Gaiellales | *norank\_f\_\_norank\_o\_\_Gaiellales* |
| *uncultured\_Acidimicrobiales\_bacterium\_g\_\_norank\_f\_\_norank* | Actinobacteriota | Acidimicrobiia | IMCC26256 | norank\_o\_\_IMCC26256 | *norank\_f\_\_norank\_o\_\_IMCC26256* |
| *uncultured\_Chloroflexi\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_AD3* | Chloroflexi | AD3 | norank\_c\_\_AD3 | norank\_o\_\_norank\_c\_\_AD3 | *norank\_f\_\_norank\_o\_\_norank\_c\_\_AD3* |
| *uncultured\_Acidobacteria\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Subgroup\_2* | Acidobacteriota | Acidobacteriae | Subgroup\_2 | norank\_o\_\_Subgroup\_2 | *norank\_f\_\_norank\_o\_\_Subgroup\_2* |
| *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_JG36-TzT-191* | Proteobacteria | Gammaproteobacteria | JG36-TzT-191 | norank\_o\_\_JG36-TzT-191 | *norank\_f\_\_norank\_o\_\_JG36-TzT-191* |
| *unclassified\_g\_\_norank\_f\_\_SC-I-84* | Proteobacteria | Gammaproteobacteria | Burkholderiales | SC-I-84 | *norank\_f\_\_SC-I-84* |
| *uncultured\_Acidobacteria\_bacterium\_g\_\_Bryobacter* | Acidobacteriota | Acidobacteriae | Bryobacterales | Bryobacteraceae | *Bryobacter* |
| *uncultured\_bacterium\_g\_\_Aquisphaera* | Planctomycetota | Planctomycetes | Isosphaerales | Isosphaeraceae | *Aquisphaera* |
| **3500, 4300 m** |  |  |  |  |  |
| *unclassified\_o\_\_Acidobacteriales* | Acidobacteriota | Acidobacteriae | Acidobacteriales | unclassified\_o\_\_Acidobacteriales | *unclassified\_o\_\_Acidobacteriales* |
| *unclassified\_f\_\_Micromonosporaceae* | Actinobacteriota | Actinobacteria | Micromonosporales | Micromonosporaceae | *unclassified\_f\_\_Micromonosporaceae* |
| *bacterium\_Ellin6089* | Proteobacteria | Alphaproteobacteria | norank\_c\_\_Alphaproteobacteria | norank\_o\_\_norank\_c\_\_Alphaproteobacteria | *norank\_f\_\_norank\_o\_\_norank\_c\_\_Alphaproteobacteria* |
| *uncultured\_bacterium\_g\_\_norank\_f\_\_Ilumatobacteraceae* | Actinobacteriota | Acidimicrobiia | Microtrichales | Ilumatobacteraceae | *norank\_f\_\_Ilumatobacteraceae* |
| *unclassified\_g\_\_norank\_f\_\_A0839* | Proteobacteria | Alphaproteobacteria | Rhizobiales | A0839 | *norank\_f\_\_A0839* |
| *unclassified\_g\_\_GOUTA6* | Proteobacteria | Gammaproteobacteria | Burkholderiales | Nitrosomonadaceae | *GOUTA6* |
| *uncultured\_gamma\_proteobacterium\_g\_\_Acidibacter* | Proteobacteria | Gammaproteobacteria | Gammaproteobacteria\_Incertae\_Sedis | unclassified\_o\_\_Gammaproteobacteria\_Incertae\_Sedis | *Acidibacter* |
| *uncultured\_bacterium\_g\_\_Luedemannella* | Actinobacteriota | Actinobacteria | Micromonosporales | Micromonosporaceae | *Luedemannella* |
| *Ilyonectria\_rufa* | Ascomycota | Sordariomycetes | Hypocreales | Nectriaceae | *Ilyonectria* |
| *unclassified\_g\_\_norank\_f\_\_Gemmatimonadaceae* | Gemmatimonadota | Gemmatimonadetes | Gemmatimonadales | Gemmatimonadaceae | *norank\_f\_\_Gemmatimonadaceae* |
| *uncultured\_planctomycete\_g\_\_norank\_f\_\_Gemmataceae* | Planctomycetota | Planctomycetes | Gemmatales | Gemmataceae | *norank\_f\_\_Gemmataceae* |
| *uncultured\_beta\_proteobacterium\_g\_\_norank\_f\_\_SC-I-84* | Proteobacteria | Gammaproteobacteria | Burkholderiales | SC-I-84 | *norank\_f\_\_SC-I-84* |
| *uncultured\_bacterium\_g\_\_Luedemannella* | Actinobacteriota | Actinobacteria | Micromonosporales | Micromonosporaceae | *Luedemannella* |
| *Ilyonectria\_rufa* | Ascomycota | Sordariomycetes | Hypocreales | Nectriaceae | *Ilyonectria* |

**Table S****4.** Neighbors of specie CO3- and TN in bacterial (fungal)-soil co-occurrence network

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Species** | **Target** | **Phylum** | **r\_value** | **p\_value** |
| **Fungi** |  |  |  |  |
| *Clavaria* sp | CO3- | Ascomycota | 0.810655413 | 1.40E-05 |
| **Bacteria** |  |  |  |  |
| *uncultured\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_KD4-96* | CO3- | Chloroflexi | 0.696543 | 0.000683 |
| *metagenome\_g\_\_norank\_f\_\_norank\_o\_\_Gaiellales* | CO3- | Actinobacteriota | 0.830623 | 0.000006 |
| *uncultured\_forest\_soil\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Subgroup\_2* | CO3- | Acidobacteriota | -0.717996 | 0.000449 |
| *unclassified\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_KD4-96* | CO3- | Chloroflexi | 0.609392 | 0.004676 |
| *uncultured\_bacterium\_g\_\_Roseiarcus* | CO3- | Proteobacteria | -0.60001 | 0.005625 |
| *uncultured\_forest\_soil\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_norank\_c\_\_Acidimicrobiia* | CO3- | Actinobacteriota | -0.67241 | 0.001146 |
| *metagenome\_g\_\_norank\_f\_\_TRA3-20* | CO3- | Proteobacteria | 0.61744 | 0.00395 |
| *uncultured\_bacterium\_g\_\_Acidothermus* | CO3- | Actinobacteriota | -0.75286 | 0.000146 |
| *uncultured\_planctomycete\_g\_\_norank\_f\_\_Gemmataceae* | CO3- | Planctomycetota | -0.685817 | 0.000859 |
| *uncultured\_Acidimicrobiales\_bacterium\_g\_\_norank\_f\_\_norank* | CO3- | Actinobacteriota | 0.663023 | 0.001421 |
| *uncultured\_forest\_soil\_bacterium\_g\_\_norank\_f\_\_norank\_o\_\_Acidobacteriales* | TOC | Acidobacteriota | 0.711292 | 0.000517 |
| *uncultured\_Acidobacteria\_bacterium\_g\_\_Occallatibacter* | TOC | Acidobacteriota | 0.64151 | 0.00236 |
| *unclassified\_g\_\_Iamia* | TOC | Actinobacteriota | -0.61827 | 0.003894 |
| *uncultured\_Acidimicrobiales\_bacterium\_g\_\_norank\_f\_\_norank* | TOC | Actinobacteriota | -0.709951 | 0.000525 |
| *uncultured\_bacterium\_g\_\_Luedemannella* | TOC | Actinobacteriota | -0.811633 | 0.000012 |