• 森林动态监测样地专题 •

宝天曼落叶阔叶林土壤细菌多样性

赵爱花^{1,2} 杜晓军^{1*} 臧 婧¹ 张守仁¹ 焦志华³

1 (中国科学院植物研究所植被与环境变化国家重点实验室, 北京 100093)

2 (中国科学院大学, 北京 100049)

3 (中国矿业大学(北京)化学与环境工程学院, 北京 100083)

摘要: 土壤微生物在森林生态系统中起着重要作用。高通量测序方法的出现为进一步认识土壤微生物提供了契机。本文利用Illumina Miseq高通量测序技术对宝天曼森林土壤的细菌多样性进行了初步研究。结果显示: 在31个采样点内, 随着采样点增加, 检测出不同分类水平的土壤细菌类群也在增多, 当采样点达到31个时, 检测出的土壤细菌类群达到45门163纲319目495科785属和42,632个OTU; 31个土壤样品中所检测出的细菌类群平均有34.2门114.7纲215.2目323.7科446.6属5,924.7个OTU, 其中门、纲、目分类水平上的优势类群(所占比例)分别为变形菌门(Proteobacteria)(38.30%)、 α -变形菌纲(α -Proteobacteria)(18.08%)、根瘤菌目(Rhizobiales)(10.62%)。这些初步研究结果表明在一定程度上宝天曼森林土壤有较高的细菌多样性水平, 为进一步认识森林土壤细菌多样性与植物多样性关系等奠定了基础。

关键词: 森林, 土壤微生物, 细菌多样性, 高通量测序, 变形菌门, α -变形菌纲, 根瘤菌目, 宝天曼国家级自然保护区

Soil bacterial diversity in the Baotianman deciduous broad-leaved forest

Aihua Zhao^{1,2}, Xiaojun Du^{1*}, Jing Zang¹, Shouren Zhang¹, Zhihua Jiao³

1 State Key Laboratory of Vegetation and Environmental Change, Institute of Botany, Chinese Academy of Sciences, Beijing 100093

2 University of Chinese Academy of Sciences, Beijing 100049

3 School of Chemical and Environmental Engineering, China University of Mining & Technology (Beijing), Beijing 100083

Abstract: Soil microbes play an essential role in forest ecosystems. The development of the high-throughput sequencing method provides an invaluable opportunity to further understand soil microbial communities. In this study, we investigated soil bacterial diversity in the Baotianman forest using the Illumina Miseq platform. Results showed that in the 31 soil sampling points, the number of bacterial taxa detected at different classification levels increased with increasing number of sampling points. When all 31 samples were considered, the number of relative bacterial groups included 45 phyla, 163 classes, 319 orders, 495 families, 785 genera and 42,632 OTUs. The mean values of relative bacterial taxa in the 31 samples were 34.2 phyla, 114.7 classes, 215.2 orders, 323.7 families, 446.6 genera, and 5,924.7 OTUs. At the classification level of phylum, class and order, the dominant groups were Proteobacteria (38.30%), α -Proteobacteria (18.08%), and Rhizobiales (10.62%), respectively. These preliminary findings suggest that Baotianman forest soils have high levels of bacterial diversity to some degree and provide basic information and knowledge to further understand the relationship between soil bacterial diversity and plant diversity and other related scientific questions.

Key words: forest, soil microbe, bacterial diversity, high-throughput sequencing, Proteobacteria, α -Proteobacteria, Rhizobiales, Baotianman National Nature Reserve

微生物是地球上多样性最高的生命形式(Fierer & Jackson, 2006), 其分布也最为广泛, 几乎分布到

地球上的所有生境(郭良栋, 2012)。土壤是最丰富的微生物资源库, 其微生物数量庞大、生态功能活跃

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* 通讯作者 Author for correspondence. E-mail: xjdu@ibcas.ac.cn

(蔡晨秋等, 2011)。土壤微生物在生态系统中扮演着重要的角色, 调节植物健康和土壤肥力, 影响许多重要的生态过程, 比如植物对养分的获取, 氮、碳、磷、硫、金属元素等物质的生物地球化学循环, 土壤的形成, 环境污染物的生物降解等(van der Heijden *et al.*, 2008; He *et al.*, 2011; Fierer *et al.*, 2012)。而细菌又在土壤微生物中占绝对优势(顾峰雪等, 2000; 赵先丽等, 2007; Delmont *et al.*, 2012; Fierer *et al.*, 2012), 其所占比例与土壤理化性质、土壤深度等诸多因素有关, 有时甚至高达95%以上(顾峰雪等, 2000)。土壤细菌又是陆地生态系统中几乎所有生物地球化学循环的重要驱动者, 参与了土壤中大多数养分的转化(Nacke *et al.*, 2011)。相对于农田和草地生态系统来说, 森林生态系统中的土壤细菌群落仍然没有被充分研究(Li *et al.*, 2014)。森林生态系统地下具有丰富的微生物资源: 在门的分类水平上, 森林土壤细菌多样性虽不如草地(Nacke *et al.*, 2011), 但却高于农田(Roesch *et al.*, 2007)。有研究报道, 不同的自然森林类型其土壤细菌的优势类群不同(Li *et al.*, 2014), 有研究发现变形菌是温带森林土壤细菌中含量最丰富的类群(Zhang *et al.*, 2014b), 也有研究发现酸杆菌是温带森林土壤细菌中相对丰度最高的类群(Fierer *et al.*, 2012)。

以往对于土壤微生物的研究方法有很多, 如传统的平板培养法、Biolog微平板法、磷脂脂肪酸谱图分析法(PLFA)、基于核酸分子杂交技术的方法、基于PCR技术的方法(蔡晨秋等, 2011)及Sanger测序等。这些方法的应用促进了微生物生态学等相关学科的发展, 但是这些方法仅能测定土壤中部分微生物种类, 很难发现稀有种类微生物, 因此土壤微生物仍常常被看作“黑箱”(Tiedje *et al.*, 1999; Macrae, 2000; Fernando & Li, 2012)。高通量测序技术(也被称为第二代测序技术)的发展, 为人们认识土壤微生物多样性提供了新的契机。在多种高通量测序技术中, 罗氏454测序技术和Illumina测序技术的应用比较多, 而Illumina测序技术具有低错误率、低成本和高通量的优点(孙欣等, 2013), 使得简单、快速、较准确地获取土壤微生物信息成为可能, 现已基本取代454测序技术。本研究使用Illumina测序技术开展了森林土壤微生物多样性研究。

森林土壤细菌或微生物群落调查的第一步是

获得一定数量的森林土壤样品, 且这些样品能够代表它们所在的群落。目前的研究中有每样地或样方采集1个(Fierer & Jackson, 2006; Fierer *et al.*, 2012; Zhang *et al.*, 2014a, b)、3个(Jiang *et al.*, 2010; Wu *et al.*, 2013)、10个(Hackl *et al.*, 2004, 2005)、36个(Li *et al.*, 2014)等不同数量的土壤样品。那么究竟多少个土壤样品才能充分反映森林土壤微生物群落的信息呢? 这是一个基本且重要的问题(Wooley *et al.*, 2010), 同时也是一个需要进一步研究的问题。

宝天曼国家级自然保护区地处暖温带向北亚热带的过渡区, 主要植被类型为暖温带落叶阔叶林, 地理位置特殊、生境类型多样、生物多样性十分丰富(宋朝枢, 1994), 是进行森林生态学和生物多样性相关研究的理想场所。本文采用Illumina公司Miseq测序仪对位于宝天曼保护区内的25 ha森林固定样地土壤细菌多样性进行了初步研究, 以期回答以下问题: (1)宝天曼森林土壤细菌多样性水平如何? (2)宝天曼森林土壤细菌的门、纲、目、科、属等不同分类水平的优势类群有哪些? 各类群相对丰度是多少? (3)取样数量对土壤细菌多样性检测结果有何影响? 即随着取样数量增多, 土壤细菌多样性如何变化? 对这些问题的回答将有助于土壤细菌多样性及其与植物多样性的关系等的进一步研究。

1 材料与方法

1.1 研究区概况与土壤样品采集

宝天曼国家级自然保护区位于河南省南阳市内乡县境内, 地理坐标为33°25′–33°33′ N, 111°53′–112° E之间。地处南暖温带向北亚热带的过渡区域, 是中原地带少有的保存较完整的森林, 区域内生境类型多样、物种丰富。年均气温15.1℃, 年均降水量885.6 mm, 年均相对湿度68%。区内土壤主要分为山地棕壤土、山地黄棕壤土和山地褐土3个类型, 土壤pH值5.5–7.2 (宋朝枢, 1994)。25 ha (500 m × 500 m)宝天曼森林动态监测样地建于2009年, 位于宝天曼国家级自然保护区内, 主要森林类型为暖温带落叶阔叶林。我们于2013年夏季在宝天曼样地中选取了31个采样点(图1), 在每个点附近的土壤表层(深度为0–10 cm)用土钻取10–15钻土, 混合均匀、去除根和石头, –80℃保存用于DNA的提取和后续实验。

图1 25 ha宝天曼森林动态监测样地31个土壤微生物采样点位置

Fig. 1 Location of the 31 soil samples in the 25 ha Baotianman Forest Dynamics Plot

1.2 DNA提取、扩增和高通量测序

土壤微生物宏基因组提取用的是PowerSoil[®] DNA Isolation Kit (美国MoBio公司)试剂盒。采用引物 515F (5'-GTGCCAGCMGCCGCGGTAA-3') 和 806R (5'-GGACTACHVGGGTWTCTAAT-3')对16S rRNA基因的V4高变区进行PCR扩增,所用的方法为样品标记法(Caporaso *et al.*, 2011, 2012)。PCR反应体系50 μ L: 0.5 μ L TaKaRa LA Taq (5 U/ μ L), 5 μ L 10 $\times$ LA PCR Buffer II (Mg²⁺ Plus), 5 μ L dNTP Mixture (各2.5 mM), 2 μ L模板DNA, 1 μ L引物X2 (20 μ M), 36.5 μ L灭菌蒸馏水。PCR反应条件为95 $^{\circ}$ C 5 min; 95 $^{\circ}$ C 30 s, 54 $^{\circ}$ C 30 s, 72 $^{\circ}$ C 30 s, 共30个循环; 72 $^{\circ}$ C 10 min; 16 $^{\circ}$ C 10 min。将纯化后质量合格的PCR产物进行DNA文库的构建。建库成功后挑取克隆子,利用Illumina公司Miseq台式测序仪2 $\times$ 250 bp双末端测序法进行测序。

1.3 高通量测序数据处理与统计分析

高通量测序得到的原始数据经过FastQC (<http://www.bioinformatics.babraham.ac.uk/projects/fastqc/>)质量控制,然后用FLASH (<http://ccb.jhu.edu/software/FLASH/>) (Magoč & Salzberg, 2011)将有overlap的一对双末端reads进行拼接,过滤掉低质量的序列。使用QIIME (版本1.8.0)(Caporaso *et al.*, 2010)将样品标准化为每样品36,000条序列,依据惯例(Stackebrandt & Goebel, 1994)将相似性不低于97%的序列聚类成为OTU (operational taxonomic

unit)。为了高效地得到样品中微生物组成的多样性信息,我们从每个OTU中选择1条代表序列,使用RDP classifier (版本2.2)(Cole *et al.*, 2014)依据GreenGenes数据库为每条代表序列分配分类单元;再用QIIME (Caporaso *et al.*, 2010)进行单样品组成分析,得到样品在不同分类水平上的细菌类群组成及相对丰度的数据,将其中无法鉴定到这个分类水平的类群合并统称为未知类群(Unknown),将相对丰度低于1%的类群合并统称为其他类群(Others),然后制作不同分类水平上的细菌优势类群相对丰度图。

在上述基础上制作采样点数-土壤细菌类群数曲线。具体的做法是:从31个样品中随机抽取1个样品,记下这个样品中包含的细菌类群数目;然后从剩下的30个样品中再随机抽取1个样品数据,和第一个抽到的样品数据合并,记下这2个样品中包含的细菌类群数目;依此类推,直至采样点的数目达到最大;重复99次取平均值,制作采样点数-土壤细菌类群曲线。

本研究其他的数据分析与图形制作使用R 3.1.2软件(R-Development Core Team, 2014)完成。

2 结果

2.1 高通量测序原始数据处理

测序原始数据为两端各得到10,223,657条reads,拼接并进行预处理、质控后剩余9,530,983条序列。预设每个样品40,000条序列,然后去除嵌合体,去除Singleton (只有1条序列的那些OTU),并标准化为每样品36,000条序列,得到每个样品的序列数及OTU数(表1)。

2.2 土壤细菌分类

对宝天曼样地31个土壤样品进行高通量测序,共产生42,632个OTU。与数据库比对不上的OTU即未分配的部分(Unassigned)约占总数的0.76%。31个土壤样品中平均有5,924.7 $\pm$ 94.9个OTU,其中单个样品最多的有6,979个、最少的有4,971个,分属于45门163纲319目495科785属,细菌分类群详细信息见附录1(不包含未分配的部分;在每个分类水平上未有明确分类名称信息的也算作1个计入其中)。

2.2.1 门

31个土壤样品中平均有细菌34.2 $\pm$ 0.40门,其中单个样品最多的有39门,最少的有30门(图2)。检

表1 样品序列数及OTU数
Table 1 Sequence numbers and OTU numbers of individual samples

样品编号 Sample identity	原始序列数 Original sequence number	原始OTU数 Original OTU number	标准化序列数 Even sequence number	标准化后OTU数 Even OTU number
0101	37,569	7,148	36,000	6,979
0105	39,949	5,671	36,000	5,320
0203	39,698	5,661	36,000	5,327
0218	39,337	5,579	36,000	5,320
0306	39,281	6,396	36,000	6,097
0318	39,760	6,263	36,000	5,906
0411	39,756	6,008	36,000	5,672
0606	39,636	6,642	36,000	6,286
0701	39,945	6,059	36,000	5,694
0819	39,864	6,324	36,000	5,933
0913	39,827	5,275	36,000	4,971
0919	39,720	5,958	36,000	5,645
1002	39,844	5,486	36,000	5,175
1006	39,551	6,658	36,000	6,322
1018	39,711	5,526	36,000	5,184
1104	39,746	6,380	36,000	6,036
1210	39,569	6,255	36,000	5,933
1212	39,659	6,016	36,000	5,691
1318	39,809	6,706	36,000	6,326
1405	39,825	5,910	36,000	5,547
1510	39,379	5,650	36,000	5,378
1512	37,588	5,555	36,000	5,413
1607	39,739	6,338	36,000	5,981
1615	39,212	6,246	36,000	5,978
1618	39,578	6,552	36,000	6,200
1704	39,495	6,405	36,000	6,024
1718	39,130	6,910	36,000	6,564
1808	39,739	6,833	36,000	6,498
1814	39,866	6,850	36,000	6,501
1902	39,155	7,283	36,000	6,920
1913	38,882	7,145	36,000	6,844

测到的45个门中有42个有明确分类信息, 1个分类信息有争议, 2个未有明确分类名称信息。相对丰度最高的5个门所占比例总和达到82.34%, 分别是变形菌门(Proteobacteria)(38.30%)、酸杆菌门(Acidobacteria)(24.57%)、疣微菌门(Verrucomicrobia)(9.98%)、放线菌门(Actinobacteria)(6.10%)和浮霉菌门(Planctomycetes)(3.38%)(附录2A)。

2.2.2 纲

31个土壤样品中平均有细菌114.7 ± 1.4纲, 其中单个样品最多的有131纲, 最少的有97纲(图2)。检

测到的163个纲中有120个有明确分类信息, 8个分类信息有争议, 35个未有明确分类名称信息。相对丰度最大的5个纲所占比例总和达到50.93%, 分别是α-变形菌纲(α-Proteobacteria) (18.08%)、DA052 (9.55%)、Spartobacteria (8.44%)、β-变形菌纲(β-Proteobacteria)(7.77%) 和 γ-变形菌纲 (γ-Proteobacteria) (7.10%) (附录2B)。

2.2.3 目

31个土壤样品中平均有细菌215.2 ± 2.8目, 其中单个样品最多的有250目, 最少的187目(图2)。检测到的319个目中有181个有明确分类信息, 10个分类信息有争议, 128个未有明确分类名称信息。相对丰度最大的5个目所占比例总和达到40.05%, 分别是根瘤菌目(Rhizobiales)(10.62%)、Ellin6513 (9.55%)、Chthoniobacterales (8.44%)、酸杆菌目(Acidobacteriales) (6.76%)和黄单胞菌目(Xanthomonadales) (4.69%)(附录2C)。

2.2.4 科

31个土壤样品中平均有细菌323.7 ± 3.8科, 其中单个样品最多的有370科, 最少的有288科(图2)。检测到的495个科中有191个有明确分类信息, 14个分类信息有争议, 290个未有明确分类名称信息。相对丰度最大的5个科所占比例总和达到34.05%, 分别是Ellin6513目某科(Ellin6513; f__)(9.55%)、Chthoniobacteraceae (8.44%)、生丝微菌科(Hyphomicrobiaceae)(6.16%)、Koribacteraceae (6.00%)和中华杆菌科(Sinobacteraceae)(3.90%)(附录2D)。

2.2.5 属

31个土壤样品中平均有细菌446.6 ± 5.4属, 其中单个样品最多的有511属, 最少的398属(图2)。检测到的785个属中有261个有明确分类信息, 524个未有明确分类名称信息。相对丰度最大的5个属所占比例总和达到30.87%, 分别是Ellin6513目某科某属 (Ellin6513; f__; g__)(9.55%)、DA101 (7.09%)、Koribacteraceae 科某属 (Koribacteraceae; g__)(5.50%)、红游动菌属(Rhodoplanes)(4.89%)和红螺菌科某属(Sinobacteraceae; g__)(3.85%)(附录2E)。

2.3 取样数量对土壤细菌多样性的影响

在不同的分类水平上, 随着取样点的增加, 检测出的土壤细菌类群的数目也在增加。当取样点达到31个时, 检测出的土壤细菌类群的数目达到最大, 分别为45门163纲319目495科785属42,632个

图2 宝天曼森林动态监测样地31个土壤样品中检测到的不同分类水平上的细菌数量

Fig. 2 The quantity of bacteria at different taxonomic levels in the 31 soil samples in the Baotianman Forest Dynamics Plot

OTU (图3)。

在门的分类水平上, 取样点数在1–10区间时, 检测到的细菌门数量随着取样点数量增加而快速增加; 取样点数超过10后, 门的数量增速减慢; 当取样点数为19个时, 约能检测到44个门; 取样点数在20–31区间时, 门数仅增加1个达到45个。

在纲的分类水平上, 取样点数在1–10区间时, 检测到的纲数量随着取样点数量增加而较快增加; 当取样点数超过10后, 纲数量增速减慢; 当取样点数为27个时, 检测到约162个细菌纲; 取样点数在27–31区间时, 纲数仅增加1个, 达到163个。

在目、科和属的分类水平上, 取样点数在1–10区间时, 检测到的相应细菌类群数量随着取样点数量增加而较快增加; 当取样点数超过10后, 细菌类群数目增速减慢、但增速仍较大, 且属的增速大于科的增速、科的增速大于目的增速。在OTU的分类水平上, 取样点数在1–31区间时, 检测到的细菌OTU数量随着取样点数量增加一直在较快增加(图3)。

3 讨论

本文采用Illumina公司Miseq测序仪对地处南亚热带向北亚热带过渡区的宝天曼落叶阔叶林土壤细菌多样性进行了初步研究, 列出了宝天曼森林土

壤细菌门、纲、目、科、属、OTU数量以及不同分类水平上的优势类群及其相对丰度。虽然本次调查采集的土壤样品数量有限, 但高通量测序技术的应用为进一步调查宝天曼样地内土壤细菌等微生物资源积累了经验, 并提供了新的技术支撑。在本研究中, 与数据库比对不上的OTU约占总数的0.76%, 这说明所参考的GreenGenes数据库中包含了宝天曼森林土壤细菌类群中的绝大部分。研究显示, 宝天曼森林土壤细菌在门和纲水平上的分类信息较明确(附录2A, B), 而在目、科和属的水平上尚无明确分类名称信息的类群所占比例较大(附录2C–E), 这可能与测序区间、序列长度以及比对的数据库等有关。

本研究在宝天曼森林土壤中共检测出变形菌门、酸杆菌门、疣微菌门等45门, 变形菌门是最丰富的细菌类群, 这一结果与国内外关于农田、森林和草地土壤细菌多样性的很多研究相一致(滕齐辉等, 2006; 张建萍等, 2008; Nacke *et al.*, 2011; Shen *et al.*, 2013)。宝天曼样地植被类型主要为落叶阔叶林, Zhang等(2014b)对湖北神农架的落叶阔叶林研究中也检测出变形菌门是含量最丰富的类群, 这可能说明林型也是影响土壤细菌群落的因素。Fierer等(2012)发现在温带森林中酸杆菌是土壤中含量最丰富的细菌类群, Yuan等(2014)在我国青藏草地的研究中也发现酸杆菌是土壤中含量最丰富的细菌类群, 而本研究中, 酸杆菌门含量次于变形菌门居第二位, 这也验证了杨官品等(2000)的观点: 土壤细菌具有非常丰富的多样性, 不同类型的土壤中存在各自的优势细菌类群, 同时又有相似的细菌类群。

已有土壤细菌或土壤微生物研究中采用的取样数量变化很大(如1个、3个、10个、36个样品等), 但具体到某种植被类型、生境类型或生态系统, 需要采集分析多少土壤样品才能较好地反映其微生物多样性水平, 仍是个没有很好回答的问题。值得注意的是, 在采样数量一定的情况下, 研究人员大多还采取把数个取样点土样混合后形成混合样品以增加样品的代表性(Fierer & Jackson, 2006; Jones *et al.*, 2009; Bates *et al.*, 2010; Li *et al.*, 2014)。我们的初步研究表明, 取样数量对检测出的土壤细菌类群数量有显著影响: 随着样品数量增多, 被检测出来的细菌类群数量也增多, 当达到31个样品时, 其增

图3 宝天曼森林动态监测样地31个土壤样品中检测到的不同分类水平上细菌类群数随采样点数增加的稀疏曲线

Fig. 3 Rarefaction curves of the observed bacterial quantity at different taxonomic levels varying with number of samples in the Baotianman Forest Dynamics Plot

速虽然趋缓但仍在上升,且不同分类水平的细菌类群多样性表现出类似趋势同时也有区别(图3),这说明增加土壤采样点数量应能检测出更多的细菌类群,同时也提醒我们在对不同研究比较时要注意取样数量的影响。本研究结果显示无论是哪个分类水平,当取样点数在1–10区间时,检测到的细菌类群数量均随着取样点数量增加而增加较快,这说明当取样数量较少时可能会有较多细菌类群没有检测出来。在宝天曼森林中,在门的分类水平上,19个样品基本可以代表31个样品检测出来的细菌门多样性信息;在纲的分类水平上,27个样品基本可以代表31个样品检测出来的细菌纲多样性信息;在目、科、属的分类水平上当样品数量达到31个时检测出来的相应细菌类群数仍在逐渐增加;特别是在OTU的水平上当样品数量达到31个时细菌OTU数量仍在较快速增加,推测如果增加较多样品数量,检测出来的细菌OTU数量还会有较大增加。此问题需要

进一步深入研究。

具体研究中,无论是草地(Nacke *et al.*, 2011; Yuan *et al.*, 2014)、农田(Shi *et al.*, 2010; Liu *et al.*, 2013)还是在森林(Hackl *et al.*, 2004; Jiang *et al.*, 2010; Li *et al.*, 2014)等的土壤微生物研究,均应重视取样数量对研究结果的影响。取样数量除了受研究目的、研究精度决定外,往往也受实验研究成本影响,特别是高通量测序目前的单个样品所需费用还较高的情况下。因此,在实际研究中往往需要权衡选择一定取样数量,既能满足研究目的和反映研究对象的微生物多样性水平,又能兼顾实验研究费用。

另外,文库的构建及测序深度的选择等也会对检测出的细菌类群产生影响。本研究测序深度为每样品36,000条序列,文库的覆盖率为90.48%,如果增加库容、加大测序深度,有望检测出更多的细菌类群。再者,测序区间的选择也会对结果有一定影

响,如16S rRNA基因的高变区不同,其分类信息的精确性也不同(Chakravorty *et al.*, 2007)。

Nacke等(2011)在德国的研究表明,土壤细菌群落的结构在很大程度上是受树种和土壤pH值影响的;在不同的空间尺度上,pH值对土壤细菌的多样性和群落组成均有很大的影响(Lauber *et al.*, 2009; Rousk *et al.*, 2010; Griffiths *et al.*, 2011; Fierer *et al.*, 2012)。土壤化学因子、土壤温度、植物多样性是形成森林土壤微生物群落结构的3个主要因素(Zhang *et al.*, 2014b)。森林类型也可能是影响森林土壤微生物群落组成的因素之一。是哪些环境因子影响着宝天曼森林土壤细菌群落的组成和结构?土壤细菌不同类群有什么样的功能?土壤细菌与其他生物类群之间是如何相互作用的?土壤细菌多样性与植物多样性的关系是怎样的?土壤细菌在森林群落维持上扮演着什么样的角色等?这些问题都有待进一步的研究。

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附录 Supplementary Material

附录1 宝天曼森林动态监测样地土壤细菌名录(–表示相应分类水平上没有明确分类名称信息)

Appendix 1 Soil bacteria list in the Baotianman Forest Dynamics Plot. – means without specific names at the relative classification levels.

<http://www.biodiversity-science.net/fileup/PDF/w2015-032-1.pdf>

附录2 宝天曼森林动态监测样地31个土壤样品中检测到的不同分类水平上细菌优势类群及其相对丰度(其中Unknown代表未鉴定出的类群, Others代表丰度低于1%的类群)

Appendix 2 Relative abundances of the dominant bacteria at different taxonomic levels in the 31 soil samples in the Baotianman Forest Dynamics Plot. Unknown means the taxa that can not be identified; Others represent the taxa whose relative abundances are less than 1%.

<http://www.biodiversity-science.net/fileup/PDF/w2015-032-2.pdf>

附录1 宝天曼森林动态监测样地土壤细菌名录(—表示相应分类水平上没有明确分类名称信息)

Appendix 1 Soil bacteria list in the Baotianman Forest Dynamics Plot. — means without specific names at the relative classification levels

门 Phylum	纲 Class	目 Order	科 Family	属 Genus
Planctomycetes	Planctomycetia	Pirellulales	Pirellulaceae	A17
Proteobacteria	Betaproteobacteria	Burkholderiales	Alcaligenaceae	<i>Achromobacter</i>
Proteobacteria	Alphaproteobacteria	Rhodospirillales	Acetobacteraceae	<i>Acidiphilium</i>
Proteobacteria	Alphaproteobacteria	Rhodospirillales	Acetobacteraceae	<i>Acidisoma</i>
Proteobacteria	Alphaproteobacteria	Rhodospirillales	Acetobacteraceae	<i>Acidocella</i>
Proteobacteria	Betaproteobacteria	Burkholderiales	Comamonadaceae	<i>Acidovorax</i>
Proteobacteria	Gammaproteobacteria	Pseudomonadales	Moraxellaceae	<i>Acinetobacter</i>
Actinobacteria	Actinobacteria	Actinomycetales	Streptosporangiaceae	<i>Acrocarpospora</i>
Actinobacteria	Actinobacteria	Actinomycetales	Thermomonosporaceae	<i>Actinoallomurus</i>
Actinobacteria	Actinobacteria	Actinomycetales	Thermomonosporaceae	<i>Actinocorallia</i>
Actinobacteria	Actinobacteria	Actinomycetales	Thermomonosporaceae	<i>Actinomadura</i>
Actinobacteria	Actinobacteria	Actinomycetales	Pseudonocardiaceae	<i>Actinomycetospora</i>
Actinobacteria	Actinobacteria	Actinomycetales	Micromonosporaceae	<i>Actinoplanes</i>
Bacteroidetes	Cytophagia	Cytophagales	Cytophagaceae	<i>Adhaeribacter</i>
Actinobacteria	Actinobacteria	Actinomycetales	Nocardiodaceae	<i>Aeromicrobium</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Rhodobiaceae	<i>Afifella</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Bradyrhizobiaceae	<i>Afipia</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Rhizobiaceae	<i>Agrobacterium</i>
Actinobacteria	Actinobacteria	Actinomycetales	Microbacteriaceae	<i>Agromyces</i>
Firmicutes	Bacilli	Bacillales	Alicyclobacillaceae	<i>Alicyclobacillus</i>
Proteobacteria	Gammaproteobacteria	Pseudomonadales	Moraxellaceae	<i>Alkanindiges</i>
Proteobacteria	Alphaproteobacteria	Rhodobacterales	Rhodobacteraceae	<i>Amaricoccus</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Phyllobacteriaceae	<i>Aminobacter</i>
Firmicutes	Bacilli	Bacillales	Paenibacillaceae	<i>Ammoniphilus</i>
Actinobacteria	Actinobacteria	Actinomycetales	Pseudonocardiaceae	<i>Amycolatopsis</i>
Chloroflexi	Anaerolineae	Anaerolineales	Anaerolinaceae	<i>Anaerolinea</i>
Proteobacteria	Deltaproteobacteria	Myxococcales	Myxococcaceae	<i>Anaeromyxobacter</i>
Firmicutes	Bacilli	Bacillales	Bacillaceae	<i>Anoxybacillus</i>
Proteobacteria	Gammaproteobacteria	Legionellales	Coxiellaceae	<i>Aquicella</i>
Actinobacteria	Actinobacteria	Actinomycetales	Micrococcaceae	<i>Arthrobacter</i>
Tenericutes	Mollicutes	Anaeroplasmatales	Anaeroplasmataceae	<i>Asteroleplasma</i>
Proteobacteria	Alphaproteobacteria	Caulobacterales	Caulobacteraceae	<i>Asticcacaulis</i>
Proteobacteria	Betaproteobacteria	Burkholderiales	Comamonadaceae	<i>Azohydromonas</i>
Proteobacteria	Betaproteobacteria	Rhodocyclales	Rhodocyclaceae	<i>Azospira</i>
Firmicutes	Bacilli	Bacillales	Bacillaceae	<i>Bacillus</i>
Proteobacteria	Deltaproteobacteria	Bdellovibrionales	Bacteriovoracaceae	<i>Bacteriovorax</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Bradyrhizobiaceae	<i>Balneimonas</i>
Proteobacteria	Deltaproteobacteria	Bdellovibrionales	Bdellovibrionaceae	<i>Bdellovibrio</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Xanthobacteraceae	<i>Blastochloris</i>

门 Phylum	纲 Class	目 Order	科 Family	属 Genus
Proteobacteria	Alphaproteobacteria	Sphingomonadales	Sphingomonadaceae	<i>Blastomonas</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Bradyrhizobiaceae	<i>Bosea</i>
Proteobacteria	Betaproteobacteria	Burkholderiales	Comamonadaceae	<i>Brachymonas</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Bradyrhizobiaceae	<i>Bradyrhizobium</i>
Firmicutes	Bacilli	Bacillales	Paenibacillaceae	<i>Brevibacillus</i>
Proteobacteria	Betaproteobacteria	Burkholderiales	Burkholderiaceae	<i>Burkholderia</i>
Chloroflexi	Anaerolineae	Caldilineales	Caldilineaceae	<i>Caldilinea</i>
Firmicutes	Clostridia	Clostridiales	Clostridiaceae	<i>Caloramator</i>
Bacteroidetes	Cytophagia	Cytophagales	[Amoebophilaceae]	<i>Candidatus Amoebophilus</i>
Proteobacteria	Betaproteobacteria	Burkholderiales	Burkholderiaceae	<i>Candidatus Glomeribacter</i>
Acidobacteria	Acidobacteriia	Acidobacteriales	Koribacteraceae	<i>Candidatus Koribacter</i>
Chlamydiae	Chlamydiia	Chlamydiales	Parachlamydiaceae	<i>Candidatus Protochlamydia</i>
Chlamydiae	Chlamydiia	Chlamydiales	Rhabdochlamydiaceae	<i>Candidatus Rhabdochlamydia</i>
Acidobacteria	Solibacteres	Solibacterales	Solibacteraceae	<i>Candidatus Solibacter</i>
Verrucomicrobia	[Spartobacteria]	[Chthoniobacterales]	[Chthoniobacteraceae]	<i>Candidatus Xiphinematobacter</i>
Firmicutes	Bacilli	Lactobacillales	Carnobacteriaceae	<i>Carnobacterium</i>
Actinobacteria	Actinobacteria	Actinomycetales	Micromonosporaceae	<i>Catellatospora</i>
Actinobacteria	Actinobacteria	Actinomycetales	Micromonosporaceae	<i>Catenuloplanes</i>
Proteobacteria	Alphaproteobacteria	Caulobacterales	Caulobacteraceae	<i>Caulobacter</i>
Actinobacteria	Actinobacteria	Actinomycetales	Cellulomonadaceae	<i>Cellulomonas</i>
Proteobacteria	Gammaproteobacteria	Alteromonadales	Alteromonadaceae	<i>Cellvibrio</i>
Bacteroidetes	[Saprospirae]	[Saprospirales]	Chitinophagaceae	<i>Chitinophaga</i>
Bacteroidetes	Flavobacteriia	Flavobacteriales	[Weeksellaceae]	<i>Chryseobacterium</i>
Verrucomicrobia	[Spartobacteria]	[Chthoniobacterales]	[Chthoniobacteraceae]	<i>Chthoniobacter</i>
Firmicutes	Clostridia	Clostridiales	Clostridiaceae	<i>Clostridium</i>
Firmicutes	Bacilli	Bacillales	Paenibacillaceae	<i>Cohnella</i>
Actinobacteria	Thermoleophilia	Solirubrobacterales	Conexibacteraceae	<i>Conexibacter</i>
Firmicutes	Clostridia	Clostridiales	Lachnospiraceae	<i>Coprococcus</i>
Proteobacteria	Gammaproteobacteria	Legionellales	Coxiellaceae	<i>Coxiella</i>
Proteobacteria	Gammaproteobacteria	Methylococcales	Crenotrichaceae	<i>Crenothrix</i>
Actinobacteria	Actinobacteria	Actinomycetales	Microbacteriaceae	<i>Cryocola</i>
Proteobacteria	Betaproteobacteria	Burkholderiales	Oxalobacteraceae	<i>Cupriavidus</i>
Bacteroidetes	Cytophagia	Cytophagales	Cytophagaceae	<i>Cytophaga</i>
Verrucomicrobia	[Spartobacteria]	[Chthoniobacterales]	[Chthoniobacteraceae]	DA101
Actinobacteria	Actinobacteria	Actinomycetales	Micromonosporaceae	<i>Dactylosporangium</i>
Proteobacteria	Betaproteobacteria	Rhodocyclales	Rhodocyclaceae	<i>Dechloromonas</i>
Firmicutes	Clostridia	Clostridiales	Peptococcaceae	<i>Dehalobacter_Syntrophobotul</i>
[Thermi]	Deinococci	Deinococcales	Deinococcaceae	<i>Deinococcus</i>
Proteobacteria	Betaproteobacteria	Burkholderiales	Comamonadaceae	<i>Delftia</i>
Actinobacteria	Actinobacteria	Actinomycetales	Dermacoccaceae	<i>Dermacoccus</i>
Proteobacteria	Deltaproteobacteria	Desulfarculales	Desulfarculaceae	<i>Desulfarculus</i>

门 Phylum	纲 Class	目 Order	科 Family	属 Genus
Proteobacteria	Deltaproteobacteria	Desulfobacterales	Desulfobulbaceae	<i>Desulfobulbus</i>
Proteobacteria	Deltaproteobacteria	Syntrophobacterales	Syntrophaceae	<i>Desulfomonile</i>
Firmicutes	Clostridia	Clostridiales	Peptococcaceae	<i>Desulfosporosinus</i>
Proteobacteria	Deltaproteobacteria	Desulfovibrionales	Desulfovibrionaceae	<i>Desulfovibrio</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Hyphomicrobiaceae	<i>Devosia</i>
Proteobacteria	Betaproteobacteria	Rhodocyclales	Rhodocyclaceae	<i>Dok59</i>
Proteobacteria	Gammaproteobacteria	Xanthomonadales	Xanthomonadaceae	<i>Dokdonella</i>
Bacteroidetes	Cytophagia	Cytophagales	Cytophagaceae	<i>Dyadobacter</i>
Bacteroidetes	Bacteroidia	Bacteroidales	Porphyromonadaceae	<i>Dysgonomonas</i>
Acidobacteria	Acidobacteriia	Acidobacteriales	Acidobacteriaceae	<i>Edaphobacter</i>
Verrucomicrobia	[Spartobacteria]	[Chthoniobacterales]	[Chthoniobacteraceae]	<i>Ellin506</i>
Proteobacteria	Gammaproteobacteria	Pseudomonadales	Moraxellaceae	<i>Enhydrobacter</i>
Firmicutes	Clostridia	Clostridiales	Lachnospiraceae	<i>Epulopiscium</i>
Proteobacteria	Gammaproteobacteria	Enterobacteriales	Enterobacteriaceae	<i>Erwinia</i>
Chloroflexi	Ktedonobacteria	Ktedonobacterales	Ktedonobacteraceae	<i>FFCH10602</i>
Armatimonadetes	[Fimbriimonadia]	[Fimbriimonadales]	[Fimbriimonadaceae]	<i>Fimbriimonas</i>
Bacteroidetes	[Saprospirae]	[Saprospirales]	Chitinophagaceae	<i>Flaviumibacter</i>
Bacteroidetes	[Saprospirae]	[Saprospirales]	Chitinophagaceae	<i>Flavisolibacter</i>
Bacteroidetes	Flavobacteriia	Flavobacteriales	Flavobacteriaceae	<i>Flavobacterium</i>
Actinobacteria	Actinobacteria	Actinomycetales	Frankiaceae	<i>Frankia</i>
Actinobacteria	Actinobacteria	Actinomycetales	Microbacteriaceae	<i>Frigoribacterium</i>
Proteobacteria	Betaproteobacteria	Gallionellales	Gallionellaceae	<i>Gallionella</i>
Planctomycetes	Planctomycetia	Gemmatales	Gemmataceae	<i>Gemmata</i>
Gemmatimonadetes	Gemmatimonadetes	Gemmatimonadales	Gemmatimonadaceae	<i>Gemmatimonas</i>
Firmicutes	Bacilli	Bacillales	Bacillaceae	<i>Geobacillus</i>
Proteobacteria	Deltaproteobacteria	Desulfuromonadales	Geobacteraceae	<i>Geobacter</i>
Actinobacteria	Actinobacteria	Actinomycetales	Geodermatophilaceae	<i>Geodermatophilus</i>
Acidobacteria	Holophagae	Holophagales	Holophagaceae	<i>Geothrix</i>
Nitrospirae	Nitrospira	Nitrospirales	[Thermodesulfovibrionaceae]	<i>GOUTA19</i>
Proteobacteria	Deltaproteobacteria	Myxococcales	Haliangiaceae	<i>Haliangium</i>
Proteobacteria	Betaproteobacteria	Burkholderiales	Oxalobacteraceae	<i>Hermiimonas</i>
Verrucomicrobia	[Spartobacteria]	[Chthoniobacterales]	[Chthoniobacteraceae]	<i>heteroC45_4W</i>
Proteobacteria	Betaproteobacteria	Burkholderiales	Comamonadaceae	<i>Hydrogenophaga</i>
Proteobacteria	Betaproteobacteria	Burkholderiales	Comamonadaceae	<i>Hylemonella</i>
Bacteroidetes	Cytophagia	Cytophagales	Cytophagaceae	<i>Hymenobacter</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Hyphomicrobiaceae	<i>Hyphomicrobium</i>
Actinobacteria	Acidimicrobiia	Acidimicrobiales	Iamiaceae	<i>Iamia</i>
Proteobacteria	Alphaproteobacteria	Rhodospirillales	Rhodospirillaceae	<i>Inquilineus</i>
Actinobacteria	Actinobacteria	Actinomycetales	Intrasporangiaceae	<i>Janibacter</i>
Proteobacteria	Betaproteobacteria	Burkholderiales	Oxalobacteraceae	<i>Janthinobacterium</i>
Nitrospirae	Nitrospira	Nitrospirales	Nitrospiraceae	<i>JG37-AG-70</i>

门 Phylum	纲 Class	目 Order	科 Family	属 Genus
Proteobacteria	Alphaproteobacteria	Rhizobiales	Rhizobiaceae	<i>Kaistia</i>
Proteobacteria	Alphaproteobacteria	Sphingomonadales	Sphingomonadaceae	<i>Kaistobacter</i>
Actinobacteria	Actinobacteria	Actinomycetales	Actinosynnemataceae	<i>Kibdelosporangium</i>
Actinobacteria	Actinobacteria	Actinomycetales	Kineosporiaceae	<i>Kineosporia</i>
Chloroflexi	Chloroflexi	[Roseiflexales]	[Kouleothrixaceae]	<i>Kouleothrix</i>
Actinobacteria	Actinobacteria	Actinomycetales	Nocardiodaceae	<i>Kribbella</i>
Actinobacteria	Actinobacteria	Actinomycetales	Actinosynnemataceae	<i>Kutzneria</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Xanthobacteraceae	<i>Labrys</i>
Bacteroidetes	Cytophagia	Cytophagales	Cytophagaceae	<i>Larkinella</i>
Proteobacteria	Gammaproteobacteria	Legionellales	Legionellaceae	<i>Legionella</i>
Spirochaetes	[Leptospirae]	[Leptospirales]	Leptospiraceae	<i>Leptonema</i>
Actinobacteria	Actinobacteria	Actinomycetales	Microbacteriaceae	<i>Leucobacter</i>
Proteobacteria	Gammaproteobacteria	Xanthomonadales	Xanthomonadaceae	<i>Luteibacter</i>
Proteobacteria	Gammaproteobacteria	Xanthomonadales	Xanthomonadaceae	<i>Luteimonas</i>
Verrucomicrobia	Verrucomicrobiae	Verrucomicrobiales	Verrucomicrobiaceae	<i>Luteolibacter</i>
Firmicutes	Bacilli	Bacillales	Planococcaceae	<i>Lysinibacillus</i>
Proteobacteria	Gammaproteobacteria	Xanthomonadales	Xanthomonadaceae	<i>Lysobacter</i>
Proteobacteria	Alphaproteobacteria	Rhodospirillales	Rhodospirillaceae	<i>Magnetospirillum</i>
Proteobacteria	Gammaproteobacteria	Oceanospirillales	Oceanospirillaceae	<i>Marinomonas</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Phyllobacteriaceae	<i>Mesorhizobium</i>
Proteobacteria	Betaproteobacteria	Burkholderiales	Comamonadaceae	<i>Methylibium</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Methylobacteriaceae	<i>Methylobacterium</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Beijerinckiaceae	<i>Methyloferula</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Methylocystaceae	<i>Methylopila</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Methylocystaceae	<i>Methylosinus</i>
Proteobacteria	Betaproteobacteria	Methylophilales	Methylophilaceae	<i>Methylotenera</i>
Actinobacteria	Actinobacteria	Actinomycetales	Microbacteriaceae	<i>Microbacterium</i>
Actinobacteria	Actinobacteria	Actinomycetales	Geodermatophilaceae	<i>Modestobacter</i>
Actinobacteria	Actinobacteria	Actinomycetales	Mycobacteriaceae	<i>Mycobacterium</i>
Proteobacteria	Alphaproteobacteria	Caulobacterales	Caulobacteraceae	<i>Mycoplana</i>
Proteobacteria	Deltaproteobacteria	Myxococcales	Myxococcaceae	<i>Myxococcus</i>
Proteobacteria	Deltaproteobacteria	Myxococcales	Nannocystaceae	<i>Nannocystis</i>
Proteobacteria	Gammaproteobacteria	Xanthomonadales	Sinobacteraceae	<i>Nevskia</i>
Bacteroidetes	[Saprospirae]	[Saprospirales]	Chitinophagaceae	<i>Niastella</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Bradyrhizobiaceae	<i>Nitrobacter</i>
Proteobacteria	Betaproteobacteria	Nitrosomonadales	Nitrosomonadaceae	<i>Nitrosovibrio</i>
Nitrospirae	Nitrospira	Nitrospirales	Nitrospiraceae	<i>Nitrospira</i>
Actinobacteria	Actinobacteria	Actinomycetales	Nocardiaceae	<i>Nocardia</i>
Actinobacteria	Actinobacteria	Actinomycetales	Nocardiodaceae	<i>Nocardioides</i>
Actinobacteria	Actinobacteria	Actinomycetales	Streptosporangiaceae	<i>Nonomuraea</i>
Planctomycetes	Planctomycetia	Gemmatales	Isosphaeraceae	<i>Nostocoida</i>

门 Phylum	纲 Class	目 Order	科 Family	属 Genus
Proteobacteria	Alphaproteobacteria	Sphingomonadales	Sphingomonadaceae	<i>Novosphingobium</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Brucellaceae	<i>Ochrobactrum</i>
Verrucomicrobia	Opitutae	Opitutales	Opitutaceae	<i>Opitutus</i>
Verrucomicrobia	[Spartobacteria]	[Chthoniobacterales]	[Chthoniobacteraceae]	OR-59
Acidobacteria	Solibacteres	Solibacterales	Other	Other
Acidobacteria	Acidobacteriia	Acidobacteriales	Acidobacteriaceae	Other
Acidobacteria	Other	Other	Other	Other
Acidobacteria	Acidobacteriia	Acidobacteriales	Koribacteraceae	Other
Actinobacteria	Actinobacteria	Actinomycetales	Micromonosporaceae	Other
Actinobacteria	Actinobacteria	Actinomycetales	Geodermatophilaceae	Other
Actinobacteria	Actinobacteria	Actinomycetales	Other	Other
Actinobacteria	Actinobacteria	Actinomycetales	Microbacteriaceae	Other
Actinobacteria	Actinobacteria	Actinomycetales	Intrasporangiaceae	Other
Actinobacteria	Thermoleophilia	Solirubrobacterales	Other	Other
Actinobacteria	Actinobacteria	Actinomycetales	Actinosynnemataceae	Other
Actinobacteria	Actinobacteria	Actinomycetales	Streptomyetaceae	Other
Actinobacteria	Actinobacteria	Actinomycetales	Micrococcaceae	Other
Actinobacteria	Actinobacteria	Actinomycetales	Streptosporangiaceae	Other
Actinobacteria	Actinobacteria	Actinomycetales	Pseudonocardiaceae	Other
Actinobacteria	Actinobacteria	Actinomycetales	Kineosporiaceae	Other
Actinobacteria	Actinobacteria	Actinomycetales	Cryptosporangiaceae	Other
Actinobacteria	Acidimicrobiia	Acidimicrobiales	Iamiaceae	Other
Actinobacteria	Actinobacteria	Actinomycetales	Thermomonosporaceae	Other
Actinobacteria	Actinobacteria	Actinomycetales	Cellulomonadaceae	Other
Actinobacteria	Thermoleophilia	Gaiellales	Other	Other
Actinobacteria	Acidimicrobiia	Acidimicrobiales	Other	Other
Actinobacteria	Actinobacteria	Actinomycetales	Frankiaceae	Other
AD3	Other	Other	Other	Other
Armatimonadetes	Chthonomonadetes	Chthonomonadales	Other	Other
Armatimonadetes	Other	Other	Other	Other
Armatimonadetes	Chthonomonadetes	Chthonomonadales	Chthonomonadaceae	Other
Armatimonadetes	[Fimbriimonadia]	[Fimbriimonadales]	[Fimbriimonadaceae]	Other
Bacteroidetes	[Saprospirae]	[Saprospirales]	Chitinophagaceae	Other
Bacteroidetes	Sphingobacteriia	Sphingobacteriales	Other	Other
Bacteroidetes	Other	Other	Other	Other
Bacteroidetes	Cytophagia	Cytophagales	Cytophagaceae	Other
Bacteroidetes	Sphingobacteriia	Sphingobacteriales	Sphingobacteriaceae	Other
Bacteroidetes	Flavobacteriia	Flavobacteriales	Cryomorphaceae	Other
Chlamydiae	Chlamydiia	Chlamydiales	Parachlamydiaceae	Other
Chlamydiae	Chlamydiia	Chlamydiales	Other	Other
Chlamydiae	Chlamydiia	Other	Other	Other

门 Phylum	纲 Class	目 Order	科 Family	属 Genus
Chlamydiae	Chlamydiia	Chlamydiales	Waddliaceae	Other
Chlamydiae	Chlamydiia	Chlamydiales	Simkaniaceae	Other
Chloroflexi	Other	Other	Other	Other
Chloroflexi	Anaerolineae	Other	Other	Other
Chloroflexi	TK10	B07_WMSP1	Other	Other
Chloroflexi	Anaerolineae	A31	Other	Other
Chloroflexi	Anaerolineae	Anaerolineales	Anaerolinaceae	Other
Firmicutes	Bacilli	Bacillales	Planococcaceae	Other
Firmicutes	Clostridia	Clostridiales	Peptostreptococcaceae	Other
Firmicutes	Bacilli	Bacillales	Bacillaceae	Other
Firmicutes	Bacilli	Bacillales	Thermoactinomycetaceae	Other
Firmicutes	Clostridia	Clostridiales	Other	Other
Firmicutes	Bacilli	Bacillales	Other	Other
Firmicutes	Bacilli	Bacillales	Sporolactobacillaceae	Other
Gemmatimonadetes	Gemmatimonadetes	Other	Other	Other
Gemmatimonadetes	Gemmatimonadetes	Gemmatimonadales	Other	Other
Nitrospirae	Nitrospira	Nitrospirales	Nitrospiraceae	Other
Other	Other	Other	Other	Other
Planctomycetes	Phycisphaerae	Phycisphaerales	Other	Other
Proteobacteria	Betaproteobacteria	Burkholderiales	Oxalobacteraceae	Other
Proteobacteria	Betaproteobacteria	Burkholderiales	Comamonadaceae	Other
Proteobacteria	Betaproteobacteria	Other	Other	Other
Proteobacteria	Alphaproteobacteria	Other	Other	Other
Proteobacteria	Betaproteobacteria	Burkholderiales	Burkholderiaceae	Other
Proteobacteria	Alphaproteobacteria	Rhizobiales	Hyphomicrobiaceae	Other
Proteobacteria	Alphaproteobacteria	Rhizobiales	Rhizobiaceae	Other
Proteobacteria	Alphaproteobacteria	Rhizobiales	Other	Other
Proteobacteria	Alphaproteobacteria	Rhizobiales	Bradyrhizobiaceae	Other
Proteobacteria	Gammaproteobacteria	Other	Other	Other
Proteobacteria	Deltaproteobacteria	Myxococcales	Polyangiaceae	Other
Proteobacteria	Betaproteobacteria	Rhodocyclales	Rhodocyclaceae	Other
Proteobacteria	Deltaproteobacteria	Myxococcales	Other	Other
Proteobacteria	Gammaproteobacteria	Legionellales	Other	Other
Proteobacteria	Alphaproteobacteria	Rhizobiales	Beijerinckiaceae	Other
Proteobacteria	Betaproteobacteria	Burkholderiales	Other	Other
Proteobacteria	Gammaproteobacteria	Xanthomonadales	Sinobacteraceae	Other
Proteobacteria	Gammaproteobacteria	Legionellales	Legionellaceae	Other
Proteobacteria	Gammaproteobacteria	Xanthomonadales	Xanthomonadaceae	Other
Proteobacteria	Alphaproteobacteria	Caulobacteriales	Caulobacteraceae	Other
Proteobacteria	Gammaproteobacteria	Enterobacteriales	Enterobacteriaceae	Other
Proteobacteria	Alphaproteobacteria	Rhizobiales	Phyllobacteriaceae	Other

门 Phylum	纲 Class	目 Order	科 Family	属 Genus
Proteobacteria	Alphaproteobacteria	Rickettsiales	mitochondria	Other
Proteobacteria	Alphaproteobacteria	Rhizobiales	Methylocystaceae	Other
Proteobacteria	Alphaproteobacteria	Rhodobacterales	Rhodobacteraceae	Other
Proteobacteria	Other	Other	Other	Other
Proteobacteria	Alphaproteobacteria	Rhizobiales	Brucellaceae	Other
Proteobacteria	Betaproteobacteria	Methylophilales	Other	Other
Proteobacteria	Deltaproteobacteria	Other	Other	Other
Proteobacteria	Betaproteobacteria	Burkholderiales	Alcaligenaceae	Other
Proteobacteria	Betaproteobacteria	Methylophilales	Methylophilaceae	Other
Proteobacteria	Gammaproteobacteria	Alteromonadales	Alteromonadaceae	Other
Proteobacteria	Alphaproteobacteria	Rhizobiales	Aurantimonadaceae	Other
Proteobacteria	Alphaproteobacteria	Sphingomonadales	Sphingomonadaceae	Other
Proteobacteria	Alphaproteobacteria	Rhodospirillales	Rhodospirillaceae	Other
Proteobacteria	Alphaproteobacteria	Rhodospirillales	Acetobacteraceae	Other
Proteobacteria	Alphaproteobacteria	Sphingomonadales	Other	Other
Proteobacteria	Deltaproteobacteria	Desulfuromonadales	Other	Other
Proteobacteria	Gammaproteobacteria	Chromatiales	Other	Other
Proteobacteria	Gammaproteobacteria	Pseudomonadales	Moraxellaceae	Other
Proteobacteria	Gammaproteobacteria	Pseudomonadales	Pseudomonadaceae	Other
Proteobacteria	Betaproteobacteria	Neisseriales	Neisseriaceae	Other
Proteobacteria	Gammaproteobacteria	Legionellales	Coxiellaceae	Other
TM6	SJA-4	Other	Other	Other
TM7	Other	Other	Other	Other
Verrucomicrobia	[Pedosphaerae]	[Pedosphaerales]	Other	Other
Verrucomicrobia	Other	Other	Other	Other
Verrucomicrobia	[Spartobacteria]	[Chthoniobacterales]	[Chthoniobacteraceae]	Other
Verrucomicrobia	[Pedosphaerae]	[Pedosphaerales]	[Pedosphaeraceae]	Other
WS3	PRR-12	Sediment-1	Other	Other
Proteobacteria	Betaproteobacteria	Burkholderiales	Oxalobacteraceae	<i>Oxalobacter</i>
Firmicutes	Bacilli	Bacillales	Paenibacillaceae	<i>Paenibacillus</i>
Firmicutes	Bacilli	Bacillales	Planococcaceae	<i>Paenisporosarcina</i>
Proteobacteria	Betaproteobacteria	Burkholderiales	Burkholderiaceae	<i>Pandoraea</i>
Chlamydiae	Chlamydiia	Chlamydiales	Parachlamydiaceae	<i>Parachlamydia</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Hyphomicrobiaceae	<i>Parvibaculum</i>
Bacteroidetes	Sphingobacteriia	Sphingobacteriales	Sphingobacteriaceae	<i>Pedobacter</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Hyphomicrobiaceae	<i>Pedomicrobium</i>
Verrucomicrobia	[Pedosphaerae]	[Pedosphaerales]	[Pedosphaeraceae]	<i>Pedosphaera</i>
Proteobacteria	Deltaproteobacteria	Desulfuromonadales	Pelobacteraceae	<i>Pelobacter</i>
Firmicutes	Clostridia	Clostridiales	Veillonellaceae	<i>Pelosinus</i>
Proteobacteria	Gammaproteobacteria	Pseudomonadales	Moraxellaceae	<i>Perlucidibaca</i>
Proteobacteria	Alphaproteobacteria	Rhodospirillales	Rhodospirillaceae	<i>Phaeospirillum</i>

门 Phylum	纲 Class	目 Order	科 Family	属 Genus
Proteobacteria	Alphaproteobacteria	Caulobacterales	Caulobacteraceae	<i>Phenyllobacterium</i>
Actinobacteria	Actinobacteria	Actinomycetales	Intrasporangiaceae	<i>Phycococcus</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Phyllobacteriaceae	<i>Phyllobacterium</i>
Proteobacteria	Betaproteobacteria	Burkholderiales	Alcaligenaceae	<i>Pigmentiphaga</i>
Actinobacteria	Actinobacteria	Actinomycetales	Micromonosporaceae	<i>Pilimelia</i>
Planctomycetes	Planctomycetia	Pirellulales	Pirellulaceae	<i>Pirellula</i>
Planctomycetes	Planctomycetia	Planctomycetales	Planctomycetaceae	<i>Planctomyces</i>
Firmicutes	Bacilli	Bacillales	Thermoactinomycetaceae	<i>Planifilum</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Methylocystaceae	<i>Pleomorphomonas</i>
Proteobacteria	Deltaproteobacteria	Myxococcales	Nannocystaceae	<i>Plesiocystis</i>
Proteobacteria	Betaproteobacteria	Burkholderiales	Comamonadaceae	<i>Polaromonas</i>
Proteobacteria	Betaproteobacteria	Procabacteriales	Procabacteriaceae	<i>Procabacter</i>
Actinobacteria	Actinobacteria	Actinomycetales	Promicromonosporaceae	<i>Promicromonospora</i>
Verrucomicrobia	Verrucomicrobiae	Verrucomicrobiales	Verrucomicrobiaceae	<i>Prostheco bacter</i>
Firmicutes	Clostridia	Clostridiales	Clostridiaceae	<i>Proteiniclasticum</i>
Proteobacteria	Gammaproteobacteria	Pseudomonadales	Pseudomonadaceae	<i>Pseudomonas</i>
Actinobacteria	Actinobacteria	Actinomycetales	Pseudonocardiaceae	<i>Pseudonocardia</i>
Proteobacteria	Gammaproteobacteria	Pseudomonadales	Moraxellaceae	<i>Psychrobacter</i>
Bacteroidetes	Bacteroidia	Bacteroidales	Rikenellaceae	PW3
Proteobacteria	Betaproteobacteria	Burkholderiales	Comamonadaceae	<i>Ramlibacter</i>
Actinobacteria	Actinobacteria	Actinomycetales	Microbacteriaceae	<i>Rathayibacter</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Rhizobiaceae	<i>Rhizobium</i>
Proteobacteria	Gammaproteobacteria	Xanthomonadales	Xanthomonadaceae	<i>Rhodanobacter</i>
Proteobacteria	Alphaproteobacteria	Rhodobacterales	Rhodobacteraceae	<i>Rhodobacter</i>
Actinobacteria	Actinobacteria	Actinomycetales	Nocardiaceae	<i>Rhodococcus</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Hyphomicrobiaceae	<i>Rhodoplanes</i>
Proteobacteria	Alphaproteobacteria	Rickettsiales	Rickettsiaceae	<i>Rickettsia</i>
Proteobacteria	Gammaproteobacteria	Legionellales	Coxiellaceae	<i>Rickettsiella</i>
Proteobacteria	Betaproteobacteria	Burkholderiales	Comamonadaceae	<i>Roseateles</i>
Proteobacteria	Alphaproteobacteria	Rhodospirillales	Acetobacteraceae	<i>Roseococcus</i>
Proteobacteria	Betaproteobacteria	Burkholderiales	Comamonadaceae	<i>Rubrivivax</i>
Actinobacteria	Actinobacteria	Actinomycetales	Microbacteriaceae	<i>Salinibacterium</i>
Proteobacteria	Betaproteobacteria	Burkholderiales	Burkholderiaceae	<i>Salinispora</i>
Bacteroidetes	[Saprospirae]	[Saprospirales]	Chitinophagaceae	<i>Sediminibacterium</i>
Bacteroidetes	[Saprospirae]	[Saprospirales]	Chitinophagaceae	<i>Segetibacter</i>
Proteobacteria	Gammaproteobacteria	Enterobacteriales	Enterobacteriaceae	<i>Serratia</i>
Firmicutes	Bacilli	Bacillales	Thermoactinomycetaceae	<i>Shimazuella</i>
Proteobacteria	Alphaproteobacteria	Rhodospirillales	Rhodospirillaceae	<i>Skermanella</i>
Firmicutes	Bacilli	Bacillales	Planococcaceae	<i>Solibacillus</i>
Bacteroidetes	Sphingobacteriia	Sphingobacteriales	Sphingobacteriaceae	<i>Solitalea</i>
Actinobacteria	Actinobacteria	Actinomycetales	Streptosporangiaceae	<i>Sphaerisporangium</i>

门 Phylum	纲 Class	目 Order	科 Family	属 Genus
Bacteroidetes	Sphingobacteriia	Sphingobacteriales	Sphingobacteriaceae	<i>Sphingobacterium</i>
Proteobacteria	Alphaproteobacteria	Sphingomonadales	Sphingomonadaceae	<i>Sphingobium</i>
Proteobacteria	Alphaproteobacteria	Sphingomonadales	Sphingomonadaceae	<i>Sphingomonas</i>
Proteobacteria	Alphaproteobacteria	Sphingomonadales	Sphingomonadaceae	<i>Sphingopyxis</i>
Spirochaetes	Spirochaetes	Spirochaetales	Spirochaetaceae	<i>Spirochaeta</i>
Bacteroidetes	Cytophagia	Cytophagales	Cytophagaceae	<i>Spirosoma</i>
Actinobacteria	Actinobacteria	Actinomycetales	Sporichthyaceae	<i>Sporichthya</i>
Bacteroidetes	Cytophagia	Cytophagales	Cytophagaceae	<i>Sporocytophaga</i>
Firmicutes	Clostridia	Clostridiales	Veillonellaceae	<i>Sporomusa</i>
Firmicutes	Bacilli	Bacillales	Planococcaceae	<i>Sporosarcina</i>
Firmicutes	Bacilli	Bacillales	Staphylococcaceae	<i>Staphylococcus</i>
Proteobacteria	Gammaproteobacteria	Xanthomonadales	Xanthomonadaceae	<i>Stenotrophomonas</i>
Proteobacteria	Gammaproteobacteria	Xanthomonadales	Sinobacteraceae	<i>Steroidobacter</i>
Proteobacteria	Betaproteobacteria	Rhodocyclales	Rhodocyclaceae	<i>Sterolibacterium</i>
Actinobacteria	Actinobacteria	Actinomycetales	Streptomyetaceae	<i>Streptacidiphilus</i>
Actinobacteria	Actinobacteria	Actinomycetales	Streptomyetaceae	<i>Streptomyces</i>
Actinobacteria	Actinobacteria	Actinomycetales	Streptosporangiaceae	<i>Streptosporangium</i>
Proteobacteria	Betaproteobacteria	Rhodocyclales	Rhodocyclaceae	<i>Sulfuritalea</i>
Firmicutes	Clostridia	Clostridiales	Symbiobacteriaceae	<i>Symbiobacterium</i>
Proteobacteria	Deltaproteobacteria	Syntrophobacterales	Syntrophobacteraceae	<i>Syntrophobacter</i>
Proteobacteria	Gammaproteobacteria	Legionellales	Legionellaceae	<i>Tatlockia</i>
Proteobacteria	Alphaproteobacteria	Rhodospirillales	Rhodospirillaceae	<i>Telmatospirillum</i>
Firmicutes	Clostridia	Clostridiales	Peptostreptococcaceae	<i>Tepidibacter</i>
Actinobacteria	Actinobacteria	Actinomycetales	Intrasporangiaceae	<i>Terracoccus</i>
Acidobacteria	Acidobacteriia	Acidobacteriales	Acidobacteriaceae	<i>Terriglobus</i>
Proteobacteria	Betaproteobacteria	Rhodocyclales	Rhodocyclaceae	<i>Thauera</i>
Proteobacteria	Betaproteobacteria	Hydrogenophilales	Hydrogenophilaceae	<i>Thiobacillus</i>
Firmicutes	Clostridia	Clostridiales	[Tissierellaceae]	<i>Tissierella_Soehngenia</i>
Proteobacteria	Gammaproteobacteria	Enterobacteriales	Enterobacteriaceae	<i>Trabulsiella</i>
Spirochaetes	Spirochaetes	Spirochaetales	Spirochaetaceae	<i>Treponema</i>
Proteobacteria	Betaproteobacteria	Rhodocyclales	Rhodocyclaceae	TS34
Firmicutes	Bacilli	Turicibacterales	Turicibacteraceae	<i>Turicibacter</i>
Spirochaetes	[Leptospirae]	[Leptospirales]	Leptospiraceae	<i>Turneriella</i>
Proteobacteria	Betaproteobacteria	Rhodocyclales	Rhodocyclaceae	<i>Uliginosibacterium</i>
Proteobacteria	Betaproteobacteria	Burkholderiales	Comamonadaceae	<i>Variovorax</i>
Actinobacteria	Actinobacteria	Actinomycetales	Micromonosporaceae	<i>Verrucosispora</i>
Actinobacteria	Actinobacteria	Actinomycetales	Micromonosporaceae	<i>Virgisporangium</i>
Chlamydiae	Chlamydiia	Chlamydiales	Waddliaceae	<i>Waddlia</i>
Proteobacteria	Alphaproteobacteria	Rickettsiales	Rickettsiaceae	<i>Wolbachia</i>
Proteobacteria	Alphaproteobacteria	Rhizobiales	Xanthobacteraceae	<i>Xanthobacter</i>
Proteobacteria	Betaproteobacteria	Rhodocyclales	Rhodocyclaceae	<i>Zoogloea</i>

门 Phylum	纲 Class	目 Order	科 Family	属 Genus
-	-	-	-	-
Acidobacteria	DA052	Ellin6513	-	-
Acidobacteria	Acidobacteriia	Acidobacteriales	Koribacteraceae	-
Acidobacteria	Solibacteres	Solibacterales	-	-
Acidobacteria	[Chloracidobacteria]	RB41	-	-
Acidobacteria	iii1-8	32-20	-	-
Acidobacteria	Acidobacteriia	Acidobacteriales	Acidobacteriaceae	-
Acidobacteria	Acidobacteria-6	iii1-15	-	-
Acidobacteria	iii1-8	DS-18	-	-
Acidobacteria	Acidobacteria-6	CCU21	-	-
Acidobacteria	Sva0725	Sva0725	-	-
Acidobacteria	[Chloracidobacteria]	RB41	Ellin6075	-
Acidobacteria	[Chloracidobacteria]	42332	-	-
Acidobacteria	-	-	-	-
Acidobacteria	S035	-	-	-
Acidobacteria	RB25	-	-	-
Acidobacteria	Acidobacteria-6	iii1-15	mb2424	-
Acidobacteria	TM1	-	-	-
Acidobacteria	Solibacteres	Solibacterales	Solibacteraceae	-
Acidobacteria	Solibacteres	Solibacterales	PAUC26f	-
Acidobacteria	iii1-8	SJA-36	-	-
Acidobacteria	[Chloracidobacteria]	Ellin7246	-	-
Acidobacteria	[Chloracidobacteria]	DS-100	-	-
Acidobacteria	Acidobacteria-5	-	-	-
Acidobacteria	Solibacteres	JH-WHS99	-	-
Acidobacteria	BPC102	MVS-40	-	-
Acidobacteria	Acidobacteria-6	iii1-15	RB40	-
Acidobacteria	AT-s54	-	-	-
Acidobacteria	[Chloracidobacteria]	PK29	-	-
Acidobacteria	EC1113	-	-	-
Acidobacteria	GAL08	-	-	-
Acidobacteria	Holophagae	Holophagales	Holophagaceae	-
Acidobacteria	Solibacteres	Solibacterales	[Bryobacteraceae]	-
Acidobacteria	PAUC37f	-	-	-
Acidobacteria	Solibacteres	Solibacterales	AKIW659	-
Acidobacteria	BPC102	-	-	-
Acidobacteria	[Chloracidobacteria]	-	-	-
Acidobacteria	iii1-8	-	-	-
Acidobacteria	Acidobacteriia	Acidobacteriales	-	-
Actinobacteria	Thermoleophilia	Gaiellales	Gaiellaceae	-
Actinobacteria	Thermoleophilia	Solirubrobacterales	-	-

门 Phylum	纲 Class	目 Order	科 Family	属 Genus
Actinobacteria	Acidimicrobiia	Acidimicrobiales	EB1017	-
Actinobacteria	Actinobacteria	Actinomycetales	-	-
Actinobacteria	Acidimicrobiia	Acidimicrobiales	-	-
Actinobacteria	Actinobacteria	Actinomycetales	Micrococcaceae	-
Actinobacteria	MB-A2-108	0319-7L14	-	-
Actinobacteria	Acidimicrobiia	Acidimicrobiales	C111	-
Actinobacteria	Thermoleophilia	Gaiellales	-	-
Actinobacteria	Actinobacteria	Actinomycetales	Frankiaceae	-
Actinobacteria	Actinobacteria	Actinomycetales	Micromonosporaceae	-
Actinobacteria	Thermoleophilia	Solirubrobacterales	Conexibacteraceae	-
Actinobacteria	Thermoleophilia	Solirubrobacterales	Solirubrobacteraceae	-
Actinobacteria	Actinobacteria	Actinomycetales	Nocardiodaceae	-
Actinobacteria	Thermoleophilia	Solirubrobacterales	Patulibacteraceae	-
Actinobacteria	Actinobacteria	Actinomycetales	Pseudonocardiaceae	-
Actinobacteria	Actinobacteria	Actinomycetales	Nakamurellaceae	-
Actinobacteria	MB-A2-108	-	-	-
Actinobacteria	Actinobacteria	Actinomycetales	Microbacteriaceae	-
Actinobacteria	Actinobacteria	Actinomycetales	Streptomycetaceae	-
Actinobacteria	Actinobacteria	Actinomycetales	Sporichthyaceae	-
Actinobacteria	Actinobacteria	Actinomycetales	Actinospicaceae	-
Actinobacteria	Rubrobacteria	Rubrobacterales	Rubrobacteraceae	-
Actinobacteria	Actinobacteria	Actinomycetales	Kineosporiaceae	-
Actinobacteria	Actinobacteria	Actinomycetales	Intrasporangiaceae	-
Actinobacteria	Actinobacteria	Micrococcales	-	-
Actinobacteria	Actinobacteria	Actinomycetales	Thermomonosporaceae	-
Actinobacteria	Thermoleophilia	Gaiellales	AK1AB1_02E	-
Actinobacteria	Actinobacteria	Actinomycetales	Cryptosporangiaceae	-
Actinobacteria	Acidimicrobiia	Acidimicrobiales	AKIW874	-
Actinobacteria	Acidimicrobiia	Acidimicrobiales	Microthrixaceae	-
Actinobacteria	Actinobacteria	Actinomycetales	Actinosynnemataceae	-
Actinobacteria	Acidimicrobiia	Acidimicrobiales	JdFBGBact	-
Actinobacteria	Actinobacteria	Actinomycetales	Geodermatophilaceae	-
Actinobacteria	OPB41	-	-	-
Actinobacteria	Actinobacteria	Actinomycetales	ACK-M1	-
AD3	ABS-6	-	-	-
AD3	JG37-AG-4	-	-	-
AD3	-	-	-	-
Armatimonadetes	Chthonomonadetes	Chthonomonadales	Chthonomonadaceae	-
Armatimonadetes	0319-6E2	-	-	-
Armatimonadetes	[Fimbriimonadia]	[Fimbriimonadales]	[Fimbriimonadaceae]	-
Armatimonadetes	Armatimonadia	FW68	-	-

门 Phylum	纲 Class	目 Order	科 Family	属 Genus
Armatimonadetes	Chthonomonadetes	SJA-22	-	-
Armatimonadetes	Armatimonadia	Armatimonadales	Armatimonadaceae	-
Armatimonadetes	OPB50	-	-	-
Armatimonadetes	[Fimbriimonadia]	[Fimbriimonadales]	-	-
Armatimonadetes	SHA-37	-	-	-
Armatimonadetes	SJA-176	RB046	-	-
Armatimonadetes	SJA-176	-	-	-
Armatimonadetes	SJA-176	GAB-B06	-	-
Bacteroidetes	[Saprospirae]	[Saprospirales]	Chitinophagaceae	-
Bacteroidetes	Sphingobacteriia	Sphingobacteriales	-	-
Bacteroidetes	Sphingobacteriia	Sphingobacteriales	Sphingobacteriaceae	-
Bacteroidetes	Cytophagia	Cytophagales	Cytophagaceae	-
Bacteroidetes	[Saprospirae]	[Saprospirales]	-	-
Bacteroidetes	[Saprospirae]	[Saprospirales]	Saprospiraceae	-
Bacteroidetes	At12OctB3	-	-	-
Bacteroidetes	Flavobacteriia	Flavobacteriales	Cryomorphaceae	-
Bacteroidetes	Bacteroidia	Bacteroidales	-	-
Bacteroidetes	Bacteroidia	Bacteroidales	Rikenellaceae	-
Bacteroidetes	Cytophagia	Cytophagales	[Amoebophilaceae]	-
Bacteroidetes	VC2_1_Bac22	-	-	-
Bacteroidetes	Bacteroidia	Bacteroidales	GZKB119	-
Bacteroidetes	Cytophagia	Cytophagales	-	-
BHI80-139	-	-	-	-
BRC1	PRR-11	-	-	-
BRC1	NPL-UPA2	-	-	-
Chlamydiae	Chlamydiia	Chlamydiales	-	-
Chlamydiae	Chlamydiia	Chlamydiales	Parachlamydiaceae	-
Chlamydiae	Chlamydiia	-	-	-
Chlamydiae	Chlamydiia	Chlamydiales	Waddliaceae	-
Chlamydiae	Chlamydiia	Chlamydiales	Chlamydiaceae	-
Chlorobi	-	-	-	-
Chlorobi	SJA-28	-	-	-
Chlorobi	OPB56	-	-	-
Chlorobi	BSV26	A89	-	-
Chlorobi	BSV26	PK329	-	-
Chlorobi	BSV26	C20	-	-
Chlorobi	Ignavibacteria	Ignavibacteriales	Ignavibacteriaceae	-
Chloroflexi	Ellin6529	-	-	-
Chloroflexi	TK10	B07_WMSP1	FFCH4570	-
Chloroflexi	Anaerolineae	SBR1031	oc28	-
Chloroflexi	S085	-	-	-

门 Phylum	纲 Class	目 Order	科 Family	属 Genus
Chloroflexi	Ktedonobacteria	Thermogemmatissporales	Thermogemmatissporaceae	-
Chloroflexi	Anaerolineae	SBR1031	A4b	-
Chloroflexi	Anaerolineae	H39	-	-
Chloroflexi	Chloroflexi	[Roseiflexales]	[Kouleothrixaceae]	-
Chloroflexi	TK17	-	-	-
Chloroflexi	Ktedonobacteria	JG30-KF-AS9	-	-
Chloroflexi	TK10	B07_WMSP1	-	-
Chloroflexi	TK10	AKYG885	5B-12	-
Chloroflexi	C0119	-	-	-
Chloroflexi	Anaerolineae	A31	S47	-
Chloroflexi	Gitt-GS-136	-	-	-
Chloroflexi	Anaerolineae	CFB-26	-	-
Chloroflexi	TK17	mle1-48	-	-
Chloroflexi	Ktedonobacteria	Ktedonobacterales	Ktedonobacteraceae	-
Chloroflexi	TK10	AKYG885	Dolo_23	-
Chloroflexi	Ktedonobacteria	TK10	-	-
Chloroflexi	Anaerolineae	SHA-20	-	-
Chloroflexi	Anaerolineae	envOPS12	-	-
Chloroflexi	Thermomicrobia	JG30-KF-CM45	-	-
Chloroflexi	Anaerolineae	WCHB1-50	-	-
Chloroflexi	TK10	-	-	-
Chloroflexi	Anaerolineae	SB-34	-	-
Chloroflexi	Chloroflexi	[Roseiflexales]	-	-
Chloroflexi	Anaerolineae	Caldilineales	Caldilineaceae	-
Chloroflexi	Thermomicrobia	Ellin6537	-	-
Chloroflexi	Anaerolineae	S0208	-	-
Chloroflexi	Ktedonobacteria	-	-	-
Chloroflexi	Anaerolineae	GCA004	-	-
Chloroflexi	Ktedonobacteria	B12-WMSP1	-	-
Chloroflexi	SHA-26	-	-	-
Chloroflexi	Chloroflexi	AKIW781	-	-
Chloroflexi	SAR202	-	-	-
Chloroflexi	P2-11E	-	-	-
Chloroflexi	Anaerolineae	-	-	-
Chloroflexi	-	-	-	-
Chloroflexi	Thermomicrobia	AKYG1722	-	-
Chloroflexi	Anaerolineae	A31	-	-
Chloroflexi	Anaerolineae	SBR1031	SJA-101	-
Chloroflexi	Anaerolineae	pLW-97	-	-
Chloroflexi	Chloroflexi	Chloroflexales	01D2Z48	-
Chloroflexi	Chloroflexi	Chloroflexales	FFCH7168	-

门 Phylum	纲 Class	目 Order	科 Family	属 Genus
Chloroflexi	Ktedonobacteria	Elev-1554	-	-
Chloroflexi	Anaerolineae	Anaerolineales	Anaerolinaceae	-
Chloroflexi	Thermomicrobia	-	-	-
Chloroflexi	Anaerolineae	SBR1031	SHA-31	-
Chloroflexi	Chloroflexi	Herpetosiphonales	-	-
Cyanobacteria	4C0d-2	MLE1-12	-	-
Cyanobacteria	ML635J-21	-	-	-
Cyanobacteria	Chloroplast	Stramenopiles	-	-
Cyanobacteria	4C0d-2	SM1D11	-	-
Cyanobacteria	Chloroplast	Streptophyta	-	-
Cyanobacteria	Chloroplast	Chlorophyta	-	-
Elusimicrobia	Elusimicrobia	FAC88	-	-
Elusimicrobia	Elusimicrobia	IIb	-	-
Elusimicrobia	Elusimicrobia	Elusimicrobiales	-	-
Elusimicrobia	Endomicrobia	-	-	-
Elusimicrobia	Elusimicrobia	MVP-88	-	-
Elusimicrobia	-	-	-	-
FBP	-	-	-	-
FCPU426	-	-	-	-
Fibrobacteres	Fibrobacteria	258ds10	-	-
Fibrobacteres	SBZC_2415	-	-	-
Firmicutes	Bacilli	Bacillales	Bacillaceae	-
Firmicutes	Bacilli	Bacillales	Planococcaceae	-
Firmicutes	Clostridia	Clostridiales	Ruminococcaceae	-
Firmicutes	Bacilli	Bacillales	-	-
Firmicutes	Clostridia	Clostridiales	Lachnospiraceae	-
Firmicutes	Clostridia	Clostridiales	Peptostreptococcaceae	-
Firmicutes	Clostridia	Clostridiales	Clostridiaceae	-
Firmicutes	Bacilli	Bacillales	Thermoactinomycetaceae	-
Firmicutes	Clostridia	Clostridiales	-	-
Firmicutes	Clostridia	Clostridiales	Gracilibacteraceae	-
Firmicutes	Bacilli	Bacillales	Alicyclobacillaceae	-
Firmicutes	Clostridia	OPB54	-	-
Firmicutes	Bacilli	Bacillales	[Exiguobacteraceae]	-
Firmicutes	Clostridia	Clostridiales	Veillonellaceae	-
Firmicutes	Bacilli	Bacillales	Paenibacillaceae	-
Firmicutes	Clostridia	Clostridiales	Christensenellaceae	-
GAL15	-	-	-	-
Gemmatimonadetes	Gemm-1	-	-	-
Gemmatimonadetes	Gemmatimonadetes	N1423WL	-	-
Gemmatimonadetes	Gemmatimonadetes	Ellin5290	-	-

门 Phylum	纲 Class	目 Order	科 Family	属 Genus
Gemmatimonadetes	Gemmatimonadetes	-	-	-
Gemmatimonadetes	Gemmatimonadetes	Gemmatimonadales	Ellin5301	-
Gemmatimonadetes	Gemmatimonadetes	KD8-87	-	-
Gemmatimonadetes	Gemm-5	-	-	-
Gemmatimonadetes	Gemmatimonadetes	C114	-	-
Gemmatimonadetes	Gemm-2	-	-	-
Gemmatimonadetes	Gemmatimonadetes	Gemmatimonadales	-	-
Gemmatimonadetes	Gemm-3	-	-	-
Gemmatimonadetes	-	-	-	-
GN02	GN07	-	-	-
GN02	3BR-5F	-	-	-
GN02	GKS2-174	-	-	-
GN02	BB34	-	-	-
GN04	MSB-5A5	-	-	-
GN04	-	-	-	-
GOUTA4	-	-	-	-
Kazan-3B-28	-	-	-	-
MVP-21	-	-	-	-
Nitrospirae	Nitrospira	Nitrospirales	0319-6A21	-
Nitrospirae	Nitrospira	Nitrospirales	[Leptospirillaceae]	-
Nitrospirae	Nitrospira	Nitrospirales	Nitrospiraceae	-
Nitrospirae	Nitrospira	Nitrospirales	-	-
Nitrospirae	Nitrospira	Nitrospirales	4-29	-
NKB19	-	-	-	-
NKB19	TSBW08	-	-	-
OD1	ZB2	-	-	-
OD1	SM2F11	-	-	-
OD1	-	-	-	-
OD1	ABY1	-	-	-
OD1	Mb-NB09	-	-	-
OP11	OP11-3	-	-	-
OP11	-	-	-	-
OP11	WCHB1-64	d153	-	-
OP11	OP11-4	-	-	-
OP11	WCHB1-64	-	-	-
OP11	OP11-1	-	-	-
OP3	koll11	-	-	-
OP3	PBS-25	-	-	-
OP3	koll11	GIF10	kpj58rc	-
PAUC34f	-	-	-	-
Planctomycetes	Planctomycetia	Gemmatales	Gemmataceae	-

门 Phylum	纲 Class	目 Order	科 Family	属 Genus
Planctomycetes	Phycisphaerae	WD2101	-	-
Planctomycetes	Planctomycetia	Gemmatales	Isosphaeraceae	-
Planctomycetes	Planctomycetia	Pirellulales	Pirellulaceae	-
Planctomycetes	OM190	agg27	-	-
Planctomycetes	Phycisphaerae	Phycisphaerales	-	-
Planctomycetes	BD7-11	-	-	-
Planctomycetes	Phycisphaerae	CPla-3	-	-
Planctomycetes	vadinHA49	p04_C01	-	-
Planctomycetes	Phycisphaerae	S-70	-	-
Planctomycetes	Phycisphaerae	Pla1	-	-
Planctomycetes	-	-	-	-
Planctomycetes	C6	MVS-107	-	-
Planctomycetes	OM190	CL500-15	-	-
Planctomycetes	Phycisphaerae	mle1-8	-	-
Planctomycetes	Pla3	-	-	-
Planctomycetes	Pla4	-	-	-
Planctomycetes	028H05-P-BN-P5	-	-	-
Planctomycetes	Phycisphaerae	CCM11a	-	-
Planctomycetes	vadinHA49	DH61	-	-
Planctomycetes	Phycisphaerae	Phycisphaerales	Phycisphaeraceae	-
Planctomycetes	Planctomycetia	B97	-	-
Planctomycetes	C6	d113	-	-
Planctomycetes	OM190	-	-	-
Planctomycetes	Phycisphaerae	AKAU3564	-	-
Planctomycetes	ODP123	-	-	-
Planctomycetes	Phycisphaerae	C86	-	-
Proteobacteria	Gammaproteobacteria	Xanthomonadales	Sinobacteraceae	-
Proteobacteria	Alphaproteobacteria	Rhodospirillales	Rhodospirillaceae	-
Proteobacteria	Alphaproteobacteria	Rhizobiales	Bradyrhizobiaceae	-
Proteobacteria	Deltaproteobacteria	Syntrophobacterales	Syntrophobacteraceae	-
Proteobacteria	Betaproteobacteria	-	-	-
Proteobacteria	Alphaproteobacteria	Ellin329	-	-
Proteobacteria	Gammaproteobacteria	Enterobacteriales	Enterobacteriaceae	-
Proteobacteria	Deltaproteobacteria	Myxococcales	-	-
Proteobacteria	Betaproteobacteria	A21b	EB1003	-
Proteobacteria	Alphaproteobacteria	Rhizobiales	Hyphomicrobiaceae	-
Proteobacteria	Betaproteobacteria	Ellin6067	-	-
Proteobacteria	Betaproteobacteria	SC-I-84	-	-
Proteobacteria	Gammaproteobacteria	Xanthomonadales	Xanthomonadaceae	-
Proteobacteria	Alphaproteobacteria	Rhizobiales	-	-
Proteobacteria	Alphaproteobacteria	-	-	-

门 Phylum	纲 Class	目 Order	科 Family	属 Genus
Proteobacteria	Alphaproteobacteria	Rhodospirillales	Acetobacteraceae	-
Proteobacteria	Betaproteobacteria	Burkholderiales	Comamonadaceae	-
Proteobacteria	Deltaproteobacteria	Myxococcales	Haliangiaceae	-
Proteobacteria	Betaproteobacteria	MND1	-	-
Proteobacteria	Betaproteobacteria	Burkholderiales	Oxalobacteraceae	-
Proteobacteria	Gammaproteobacteria	Legionellales	Coxiellaceae	-
Proteobacteria	Alphaproteobacteria	Rhizobiales	Methylocystaceae	-
Proteobacteria	Betaproteobacteria	IS-44	-	-
Proteobacteria	Alphaproteobacteria	Caulobacterales	Caulobacteraceae	-
Proteobacteria	Deltaproteobacteria	Myxococcales	Myxococcaceae	-
Proteobacteria	Alphaproteobacteria	Rhodobacterales	Hyphomonadaceae	-
Proteobacteria	Alphaproteobacteria	Rhizobiales	Beijerinckiaceae	-
Proteobacteria	Betaproteobacteria	Burkholderiales	Alcaligenaceae	-
Proteobacteria	Gammaproteobacteria	Thiotrichales	Piscirickettsiaceae	-
Proteobacteria	Gammaproteobacteria	Legionellales	-	-
Proteobacteria	Deltaproteobacteria	MIZ46	-	-
Proteobacteria	Alphaproteobacteria	Sphingomonadales	Sphingomonadaceae	-
Proteobacteria	Deltaproteobacteria	Myxococcales	Polyangiaceae	-
Proteobacteria	Deltaproteobacteria	-	-	-
Proteobacteria	Gammaproteobacteria	HTCC2188	HTCC2089	-
Proteobacteria	Deltaproteobacteria	NB1-j	NB1-i	-
Proteobacteria	Deltaproteobacteria	NB1-j	MND4	-
Proteobacteria	Alphaproteobacteria	BD7-3	-	-
Proteobacteria	Deltaproteobacteria	[Entotheonellales]	[Entotheonellaceae]	-
Proteobacteria	Alphaproteobacteria	Rhizobiales	Phyllobacteriaceae	-
Proteobacteria	Alphaproteobacteria	Rickettsiales	-	-
Proteobacteria	Gammaproteobacteria	Chromatiales	Ectothiorhodospiraceae	-
Proteobacteria	Deltaproteobacteria	NB1-j	-	-
Proteobacteria	Deltaproteobacteria	Spirobacillales	-	-
Proteobacteria	Betaproteobacteria	A21b	UD5	-
Proteobacteria	Betaproteobacteria	Burkholderiales	-	-
Proteobacteria	Alphaproteobacteria	Rhizobiales	Xanthobacteraceae	-
Proteobacteria	Deltaproteobacteria	Myxococcales	OM27	-
Proteobacteria	Betaproteobacteria	Nitrosomonadales	Nitrosomonadaceae	-
Proteobacteria	TA18	CV90	-	-
Proteobacteria	Deltaproteobacteria	FAC87	-	-
Proteobacteria	Betaproteobacteria	Methylophilales	-	-
Proteobacteria	Alphaproteobacteria	Rhizobiales	Rhizobiaceae	-
Proteobacteria	Betaproteobacteria	Rhodocyclales	Rhodocyclaceae	-
Proteobacteria	Alphaproteobacteria	Rhodospirillales	-	-
Proteobacteria	Betaproteobacteria	Methylophilales	Methylophilaceae	-

门 Phylum	纲 Class	目 Order	科 Family	属 Genus
Proteobacteria	TA18	PHOS-HD29	-	-
Proteobacteria	Gammaproteobacteria	-	-	-
Proteobacteria	Deltaproteobacteria	Myxococcales	Cystobacterineae	-
Proteobacteria	Gammaproteobacteria	Legionellales	Legionellaceae	-
Proteobacteria	Alphaproteobacteria	Sphingomonadales	Erythrobacteraceae	-
Proteobacteria	Gammaproteobacteria	Chromatiales	-	-
Proteobacteria	-	-	-	-
Proteobacteria	Alphaproteobacteria	Rickettsiales	Rickettsiaceae	-
Proteobacteria	Betaproteobacteria	Procabacteriales	Procabacteriaceae	-
Proteobacteria	Deltaproteobacteria	Myxococcales	0319-6G20	-
Proteobacteria	Betaproteobacteria	Burkholderiales	Burkholderiaceae	-
Proteobacteria	Betaproteobacteria	SBla14	-	-
Proteobacteria	Deltaproteobacteria	Bdellovibrionales	Bdellovibrionaceae	-
Proteobacteria	Betaproteobacteria	Nitrosomonadales	-	-
Proteobacteria	Gammaproteobacteria	Alteromonadales	OM60	-
Proteobacteria	Betaproteobacteria	Neisseriales	Neisseriaceae	-
Proteobacteria	Deltaproteobacteria	Syntrophobacterales	Syntrophaceae	-
Proteobacteria	Gammaproteobacteria	Acidithiobacillales	-	-
Proteobacteria	Deltaproteobacteria	Bdellovibrionales	Bacteriovoracaceae	-
Proteobacteria	Alphaproteobacteria	Sphingomonadales	-	-
Proteobacteria	Betaproteobacteria	Thiobacterales	-	-
Proteobacteria	Deltaproteobacteria	Sva0853	JTB36	-
Proteobacteria	Deltaproteobacteria	NB1-j	JTB38	-
Proteobacteria	Alphaproteobacteria	Rhodobacterales	Rhodobacteraceae	-
Proteobacteria	Gammaproteobacteria	Pseudomonadales	Moraxellaceae	-
Proteobacteria	Gammaproteobacteria	Alteromonadales	125ds10	-
Proteobacteria	Deltaproteobacteria	Desulfobacterales	Desulfobulbaceae	-
Proteobacteria	Deltaproteobacteria	Desulfovibrionales	Desulfovibrionaceae	-
Proteobacteria	Deltaproteobacteria	AF420338	-	-
Proteobacteria	Deltaproteobacteria	PB19	-	-
Proteobacteria	Gammaproteobacteria	PYR10d3	-	-
Proteobacteria	Alphaproteobacteria	Kiloniellales	-	-
Proteobacteria	Alphaproteobacteria	Rhizobiales	Methylobacteriaceae	-
Proteobacteria	Gammaproteobacteria	Aeromonadales	Aeromonadaceae	-
Proteobacteria	Gammaproteobacteria	Alteromonadales	211ds20	-
Proteobacteria	Gammaproteobacteria	Pseudomonadales	Pseudomonadaceae	-
Proteobacteria	Gammaproteobacteria	Thiotrichales	-	-
Proteobacteria	Gammaproteobacteria	[Marinicellales]	[Marinicellaceae]	-
Proteobacteria	Alphaproteobacteria	Rhizobiales	Aurantimonadaceae	-
Proteobacteria	Alphaproteobacteria	Rhizobiales	Bartonellaceae	-
Proteobacteria	Alphaproteobacteria	Rickettsiales	mitochondria	-

门 Phylum	纲 Class	目 Order	科 Family	属 Genus
Proteobacteria	Deltaproteobacteria	GMD14H09	-	-
Proteobacteria	Deltaproteobacteria	NKB15	-	-
Proteobacteria	Zetaproteobacteria	Mariprofundales	Mariprofundaceae	-
SBR1093	-	-	-	-
Spirochaetes	Spirochaetes	Spirochaetales	Spirochaetaceae	-
Spirochaetes	[Brevinematae]	[Brevinematales]	-	-
Spirochaetes	GN05	-	-	-
Tenericutes	Mollicutes	-	-	-
TM6	SJA-4	-	-	-
TM6	SBRH58	-	-	-
TM6	SJA-4	S1198	-	-
TM7	TM7-1	-	-	-
TM7	SC3	-	-	-
TM7	TM7-3	-	-	-
TM7	TM7-3	EW055	-	-
TM7	-	-	-	-
TM7	MJK10	-	-	-
TM7	TM7-3	I025	-	-
TM7	TM7-3	Blgi18	-	-
Verrucomicrobia	[Pedosphaerae]	[Pedosphaerales]	Ellin515	-
Verrucomicrobia	[Pedosphaerae]	[Pedosphaerales]	-	-
Verrucomicrobia	[Pedosphaerae]	[Pedosphaerales]	auto67_4W	-
Verrucomicrobia	[Methylacidiphilae]	S-BQ2-57	-	-
Verrucomicrobia	[Pedosphaerae]	[Pedosphaerales]	Ellin517	-
Verrucomicrobia	[Spartobacteria]	[Chthoniobacterales]	[Chthoniobacteraceae]	-
Verrucomicrobia	[Methylacidiphilae]	Methylacidiphilales	-	-
Verrucomicrobia	Verrucomicrobiae	Verrucomicrobiales	Verrucomicrobiaceae	-
Verrucomicrobia	Opitutae	Opitutales	Opitutaceae	-
Verrucomicrobia	[Pedosphaerae]	[Pedosphaerales]	R4-41B	-
Verrucomicrobia	[Pedosphaerae]	[Pedosphaerales]	OPB35	-
Verrucomicrobia	[Pedosphaerae]	[Pedosphaerales]	[Pedosphaeraceae]	-
Verrucomicrobia	-	-	-	-
Verrucomicrobia	Verruco-5	LD1-PB3	-	-
Verrucomicrobia	Opitutae	[Cerasicoccales]	[Cerasicoccaceae]	-
Verrucomicrobia	Verruco-5	WCHB1-41	-	-
Verrucomicrobia	Opitutae	-	-	-
Verrucomicrobia	[Methylacidiphilae]	Methylacidiphilales	LD19	-
Verrucomicrobia	[Spartobacteria]	[Chthoniobacterales]	01D2Z36	-
WPS-2	-	-	-	-
WS2	SHA-109	-	-	-
WS2	Kazan-3B-09	-	-	-

赵爱花, 杜晓军, 臧婧, 张守仁, 焦志华. 宝天曼落叶阔叶林土壤细菌多样性. 生物多样性, 2015, 23(5): 649-657.
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门 Phylum	纲 Class	目 Order	科 Family	属 Genus
WS3	PRR-12	Sediment-1	PRR-10	-
WS3	PRR-12	Sediment-1	-	-
WS3	PRR-12	LD1-PA13	-	-
WS3	PRR-12	-	-	-
WS3	PRR-12	Sediment-1	CV106	-
WS3	PRR-12	wb1_H11	-	-
WS4	-	-	-	-
ZB3	BS119	-	-	-

附录2 宝天曼森林动态监测样地31个土壤样品中检测到的不同分类水平上细菌优势类群及其相对丰度(其中Unknown代表未鉴定出的类群, Others代表丰度低于1%的类群)

Appendix 2 Relative abundances of the dominant bacteria at different taxonomic levels in the 31 soil samples in the Baotianman Forest Dynamics Plot. Unknown means the taxa that can not be identified; Others represent the taxa whose relative abundances are less than 1%.