

Phylogenetic trees of the phylum ACTINOBACTERIA
Wolfgang Ludwig¹, Jean Euzéby², and William B. Whitman³

¹*Technische Universität Muenchen, Muenchen, Germany,*
ludwig@mikro.biologie.tu-muenchen.de; ²*École Nationale Vétérinaire de Toulouse*
(ENVT), Toulouse, France, euzeby@bacterio.org; ³*University of Georgia, Athens,*
U.S.A., whitman@uga.edu

Phylogenetic analyses of the SSU rRNA sequences of representatives of the phylum *Actinobacteria* were performed to identify the major taxonomic groups. The current release of the integrated small subunit rRNA database of the SILVA project [1] provided the sequences. The tools of the ARB software package [2] were used for data evaluation, optimization and phylogenetic inference. The alignment of sequences comprising at least 1000 monomers was manually evaluated and optimized for all representatives of the phylum. Phylogenetic treeing was performed with all sequences which contain at least 1400 nucleotides and an additional 1000 sequences from representatives of the other phyla and domains. For recognizing and avoiding the influences of chimeric sequences, all calculations were performed twice, once including and once excluding environmental clone data. The data sets also varied with respect to the inclusion of highly variable sequence positions, which were eliminated in some analyses [3]. The consensus tree used for evaluating or modifying the taxonomic outline was based on maximum likelihood analyses (RAXML, implemented in the ARB package; [4]) and further evaluated by maximum parsimony and distance matrix analyses with the respective ARB tools [2]. In the case that type strains were only represented by partial sequences (less than 1400 nucleotides), the respective data were inserted by a special ARB-tool allowing the optimally positioning of branches to the reference tree without admitting topology changes.

In these consensus trees, multifurcations indicate topologies that were not resolved or when conflicting local topologies were obtained after applying alternative treeing methods or variations of program parameters.

Phylogenetic trees that are included are:

Figure 1. Type species of the *Actinobacteria*

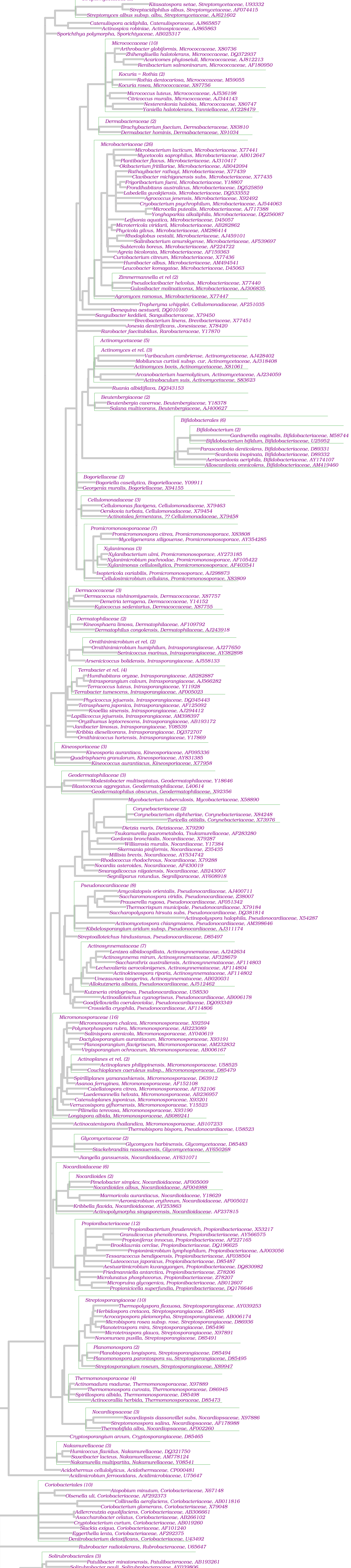
Figure 2. All species of the *Actinobacteria* except the *Streptomyces*

Figure 3. Species of the *Streptomyces*, *Kitasatospora*, and *Streptacidiphilus*

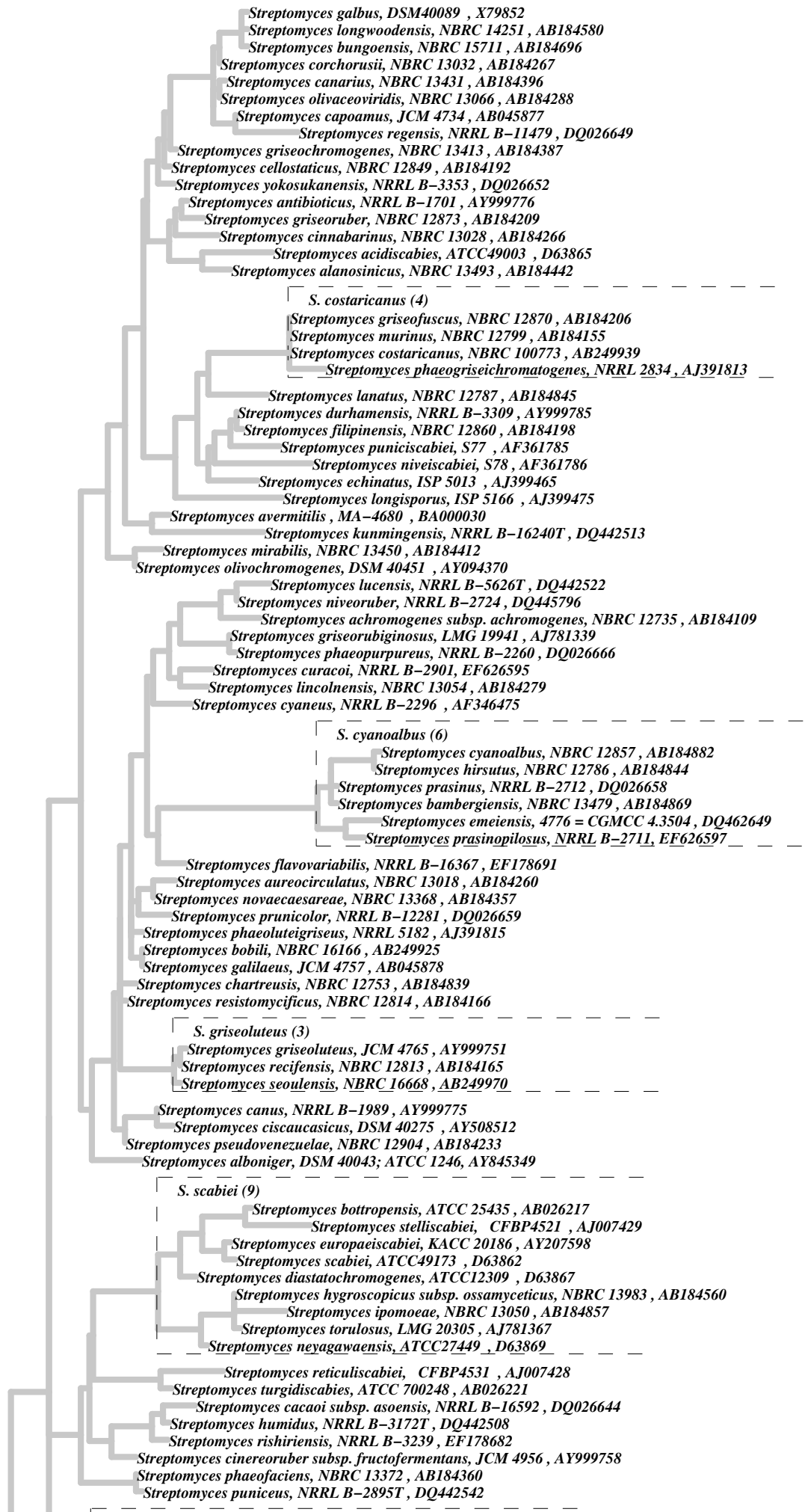
References:

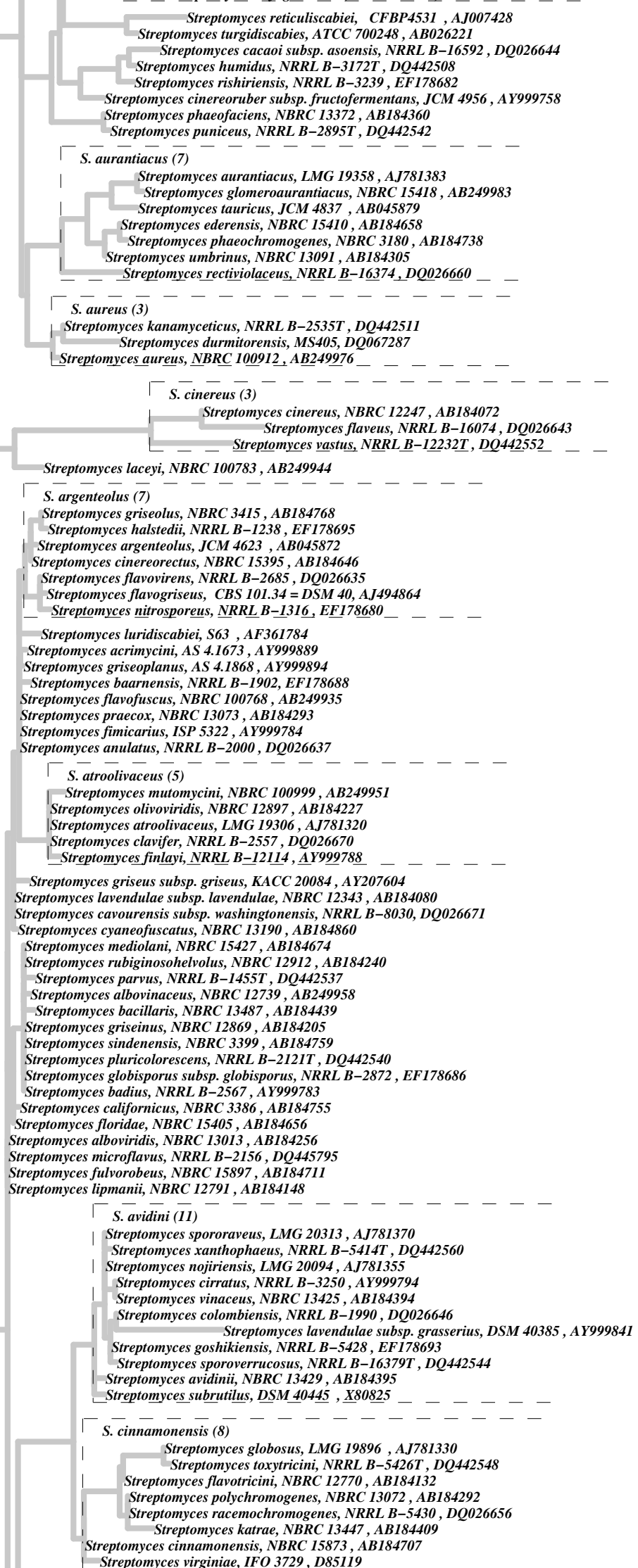
[1] Prüsse, E., Quast, C., Knittel, K., Fuchs, B., Ludwig, W., Peplies, J. and Glöckner F. O. 2007. SILVA: a comprehensive online resource for quality checked and aligned ribosomal RNA sequence data compatible with ARB. *Nuc. Acids Res.* 2007; doi: 10.1093/nar/gkm864.

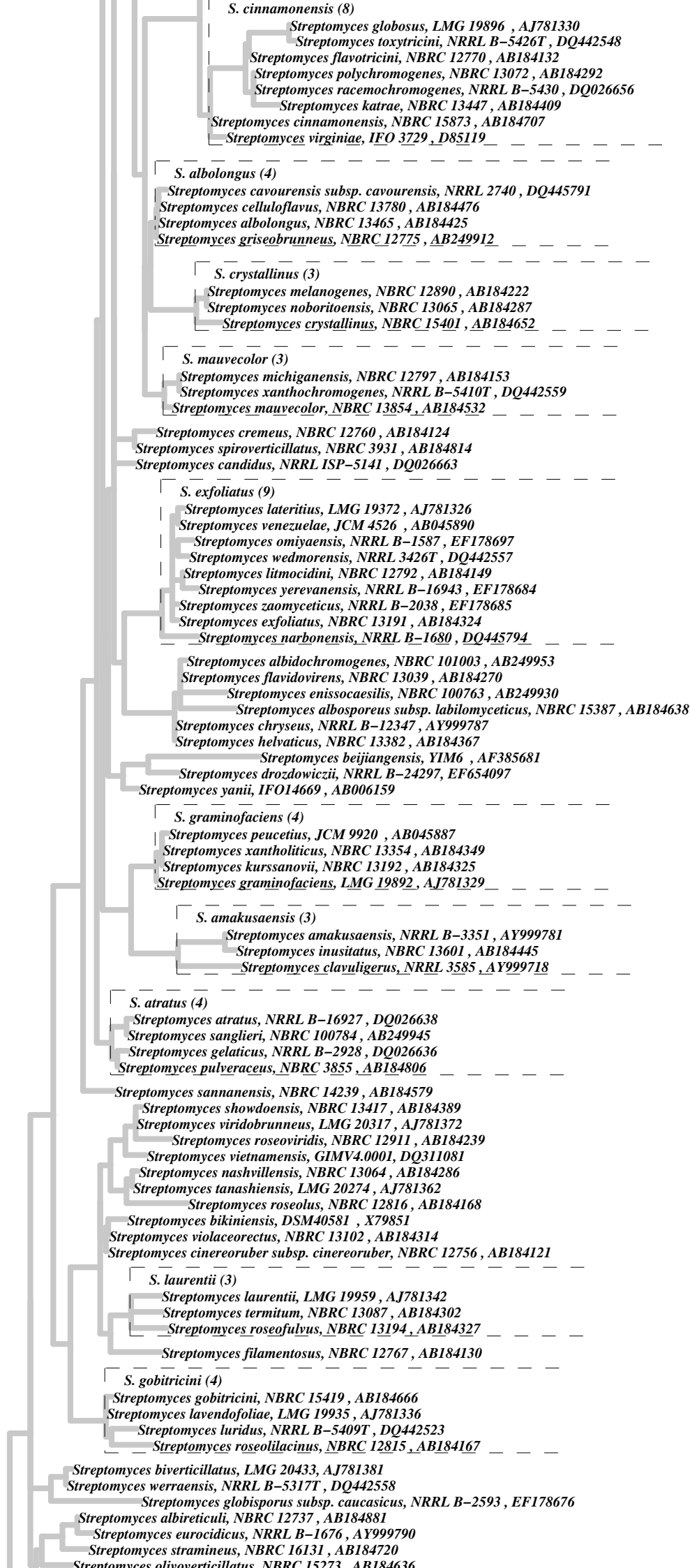
- [2] Ludwig, W., Strunk, O., Westram, R., Richter, L., and 28 others. 2004. ARB: a software environment for sequence data. *Nucleic Acids Research* 32: 1363-1371.
- [3] Ludwig, W. and Klenk, H.P. 2005. Overview: a phylogenetic backbone and taxonomic framework for Prokaryotic systematics. In: *Bergey's Manual of Systematic Bacteriology*, Vol. 2 (Garrity, G.M., Brenner, D.J., Krieg, N.R., Staley, J.T., Eds.), pp. 49- 65. Springer, New York, NY.
- [4] Stamatakis, A. P., Ludwig, T. and Meier, H. 2005. RAxML-II: A program for sequential, parallel & distributed inference of large phylogenetic trees. *Concurrency and Computation: Practice and Experience*, 17: 1705-1723.

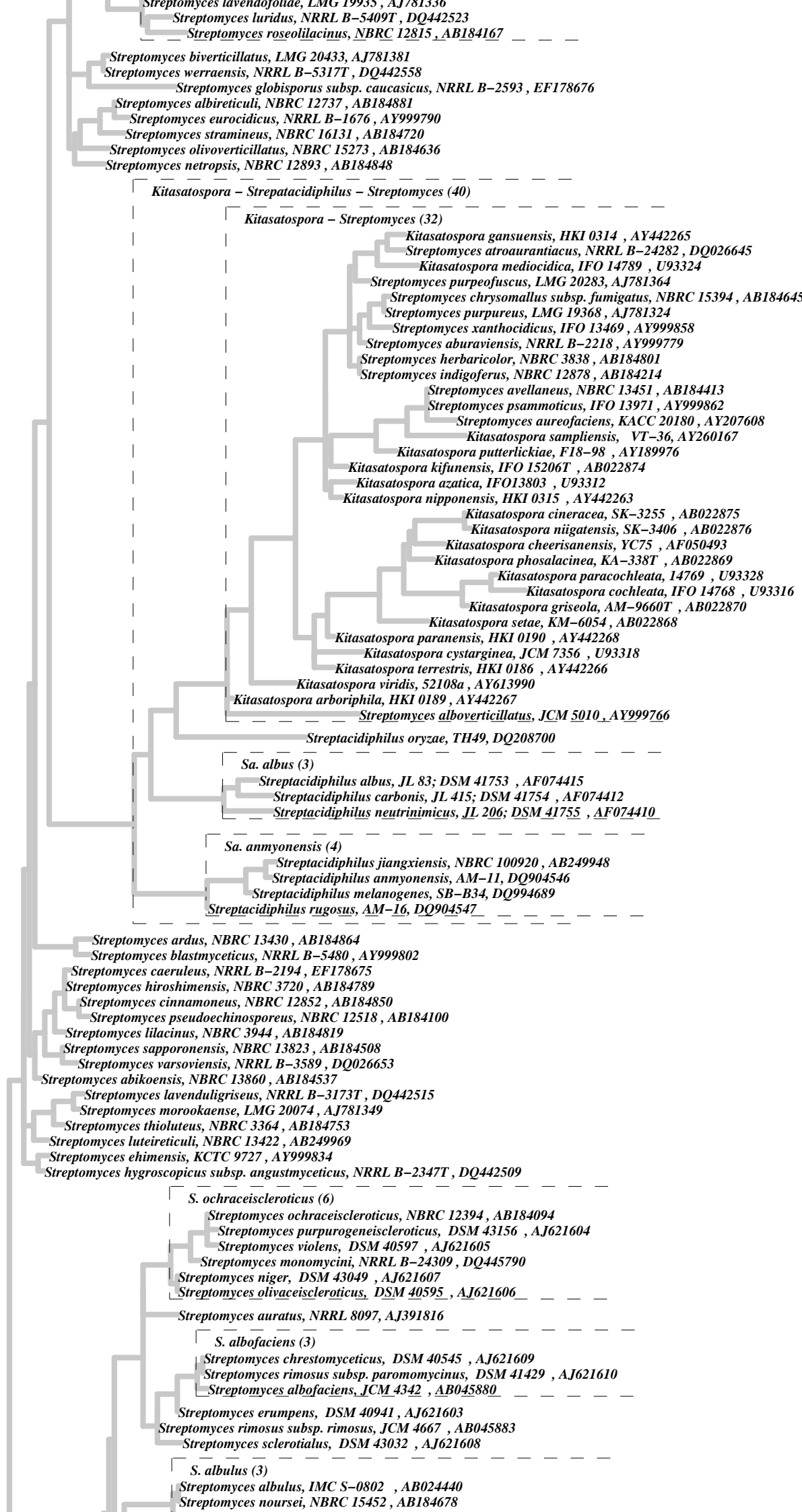


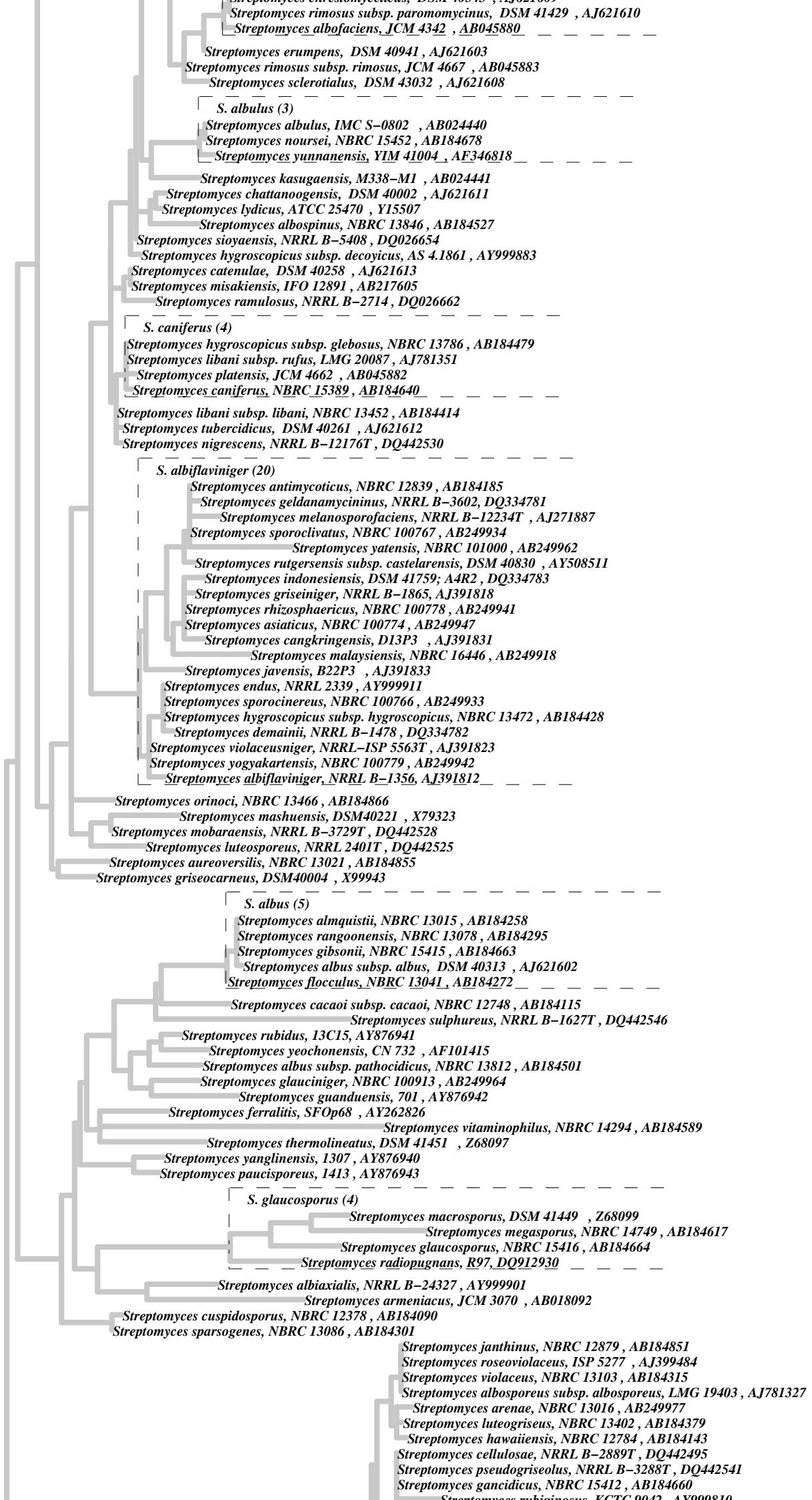












Streptomyces violaceus, ISP 5277 , AJ399484
Streptomyces violaceus, NBRC 13103 , AB184315
Streptomyces albosporeus subsp. *albosporeus*, LMG 19403 , AJ781327
Streptomyces arenae, NBRC 13016 , AB249977
Streptomyces luteogriseus, NBRC 13402 , AB184379
Streptomyces hawaiiensis, NBRC 12784 , AB184143
Streptomyces cellulosa, NRRL B-2889T , DQ442495
Streptomyces pseudogriseolus, NRRL B-3288T , DQ442541
Streptomyces gancidicus, NBRC 15412 , AB184660
Streptomyces rubiginosus, KCTC 9042 , AY999810
Streptomyces capillispiralis, NBRC 14222 , AB184577
Streptomyces lavendulocolor, NRRL B-3367T , DQ442516
Streptomyces azureus, NRRL B-2655 , EF178674
Streptomyces flavoviridis, NBRC 12772 , AB184842
Streptomyces pilosus, NBRC 12807 , AB184161
Streptomyces djakartensis, NBRC 15409 , AB184657

S. geysiriensis (7)
Streptomyces ghanaensis, KCTC 9882 , AY999851
Streptomyces minutiscleroticus, NRRL B-12202 , EF178696
Streptomyces geysiriensis, NRRL B-12102T , DQ442501
Streptomyces plicatus, NBRC 13071 , AB184291
Streptomyces rochei, NBRC 12908 , AB184237
Streptomyces vinaceusdrappus, NRRL 2363 , AY999929
Streptomyces mutabilis, NRRL ISP-5169 , EF178679

Streptomyces tuiurus, NBRC 15617 , AB184690
Streptomyces afghaniensis, ISP 5228 , AJ399483
Streptomyces africanus, CPJVR-H , AY208912

S. brasiliensis (6)
Streptomyces roseiscleroticus, NBRC 13002 , AB184251
Streptomyces ruber, NBRC 14600 , AB184604
Streptomyces spiralis, NRRL B-16922 , EF178683
Streptomyces fumigatiscleroticus, NRRL B-3856T , DQ442499
Streptomyces poonensis, NRRL B-2319 , DQ445792
Streptomyces brasiliensis, NBRC 101283 , AB249981

S. atrovirens (4)
Streptomyces atrovirens, NRRL B-16357 , DQ026672
Streptomyces caelestis, NRRL 2418 , X80824
Streptomyces fumanus, NBRC 13042 , AB184273
Streptomyces fimbriatus, DSM 40942 , AY999844

S. glaucus (5)
Streptomyces griseostramineus, NBRC 12781 , AB184140
Streptomyces griseomycini, NBRC 12778 , AB184137
Streptomyces graminearus, LMG 19904 , AJ781333
Streptomyces viridiviolaceus, IFO 13359 , AY999854
Streptomyces glaucus, NBRC 15417 , AB184665

S. aureorectus (4)
Streptomyces aureorectus, NBRC 15896 , AB184710
Streptomyces virens, NRRL B-24331T , DQ442554
Streptomyces asterosporus, NBRC 15872 , AB184706
Streptomyces calvus, NBRC 13200 , AB184329

Streptomyces naganishii, NRRL B-1816T , DQ442529
Streptomyces prasinosporus, NBRC 13419 , AB184390
Streptomyces anandii, NBRC 13438 , AB184402
Streptomyces carpinensis, NBRC 14214 , AB184574
Streptomyces levis, NBRC 15423 , AB184670
Streptomyces cinerochromogenes, NBRC 13822 , AB184507
Streptomyces koyangensis, VK-A60 , AY079156
Streptomyces violarus, NBRC 13104 , AB184316
Streptomyces daghestanicus, NRRL B-5418T , DQ442497
Streptomyces limosus, NBRC 12790 , AB184147
Streptomyces canescens, NBRC 12751 , AB184117
Streptomyces felleus, NBRC 12766 , AB184129
Streptomyces griseus subsp. *solvifaciens*, NBRC 13689 , AB249915
Streptomyces violascens, ISP 5183 , AY999737
Streptomyces hydrogenans, NBRC 13475 , AB184868
Streptomyces odorifer, DSM 40347T , Z76682
Streptomyces albidoflavus, NBRC 13010 , AB184255
Streptomyces champavatii, NRRL B-5682 , DQ026642
Streptomyces sampsonii, ATCC25495 , D63871
Streptomyces diastaticus subsp. *diastaticus*, NBRC 3714 , AB184785
Streptomyces gougerotii, NBRC 3198 , AB184742
Streptomyces rutgersensis subsp. *rutgersensis*, NBRC 12819 , AB184170
Streptomyces intermedius, NBRC 13049 , AB184277
Streptomyces indiaensis, NBRC 13964 , AB184553
Streptomyces thermocarboxydus, DSM 44293 , U94490
Streptomyces massasporeus, NBRC 12796 , AB184152
Streptomyces misionensis, NRRL B-3230 , EF178678
Streptomyces phaeoluteichromatogenes, NRRL 5799 , AJ391814
Streptomyces spectabilis, NBRC 13424 , AB184393
Streptomyces cinereospinus, NBRC 15397 , AB184648
Streptomyces coeruleofuscus, NRRL B-5417 , DQ026668
Streptomyces chromofuscus, NBRC 12851 , AB184194
Streptomyces scopiformis, NBRC 100244 , AB249927
Streptomyces spinoverrucosus, NBRC 14228 , AB184578
Streptomyces thermospinosporus, AT10 , AF333113
Streptomyces thermodiastaticus, JCM 4840 , AB018095
Streptomyces thermocarboxydovorans, DSM 44296 , U94489
Streptomyces thermoviolaceus subsp. *apingens*, DSM 41392 , Z68095
Streptomyces thermoviolaceus subsp. *thermoviolaceus*, DSM 40443 , Z68096
Streptomyces nodosus, ATCC14899 , AF114033
Streptomyces viridosporus, NRRL 2414T , DQ442556

