Supplementary Materials: Gene-Family Extension Measures and Correlations

Gon Carmi and Alexander Bolshoy

**Table S1.** Complete list of atypical genomes according to average number of paralogs 1.

|  |  |  |  |
| --- | --- | --- | --- |
| **Rank** | **Ave** | **Size (Mb)** | **Atypical Genomes** |
| 246.8 | 1.521 | 0.853 | Onion\_yellows\_phytoplasma\_OY\_M\_uid58015 |
| 66.8 | 1.835 | 2.009 | *Orientia\_tsutsugamushi*\_Ikeda\_uid58869 |
| 1225.1 | 1.915 | 2.809 | *Halalkalicoccus\_jeotgali*\_B3\_uid50305 |
| 1233.4 | 1.936 | 2.821 | *Halogeometricum\_borinquense*\_DSM |
| 1235.3 | 2.008 | 2.848 | *Haloferax volcanii*\_DS2\_uid46845 |
| 1091.1 | 1.878 | 2.914 | *Halophilic archaeon*\_DL31\_uid72619 |
| 1131.5 | 1.987 | 2.992 | *Sulfolobus solfataricus*\_P2\_uid57721 |
| 1073.9 | 2.012 | 3.155 | *Renibacterium salmoninarum*\_ATCC\_33209 |
| 1417.6 | 2.447 | 3.311 | Azospirillum\_B510\_uid46085 |
| 1240.8 | 2.067 | 3.420 | *Haloarcula marismortui*\_ATCC\_43049\_uid57719 |
| 1426.9 | 2.469 | 3.654 | *Sinorhizobium meliloti*\_1021\_uid57603 |
| 1306.5 | 2.071 | 3.668 | *Halopiger xanaduensis*\_SH\_6\_uid68105 |
| 1260.9 | 2.036 | 3.752 | *Natrialba magadii*\_ATCC\_43099\_uid46245 |
| 1401.9 | 2.407 | 3.782 | *Sinorhizobium medicae*\_WSM419\_uid58549 |
| 1419.5 | 2.378 | 3.889 | *Haloterrigena turkmenica*\_DSM\_5511 |
| 1115.8 | 2.111 | 3.911 | Novosphingobium\_PP1Y\_uid67383 |
| 1425.8 | 2.452 | 3.926 | Rhizobium\_NGR234\_uid59081 |
| 1403.3 | 2.394 | 3.928 | *Cupriavidus metallidurans*\_CH34\_uid57815 |
| 385.4 | 1.374 | 4.171 | *Sodalis glossinidius morsitans*\_\_uid58553 |
| 1346.8 | 2.200 | 4.369 | Pantoea\_At\_9b\_uid55845 |
| 1399.1 | 2.392 | 4.382 | *Rhizobium etli*\_CFN\_42\_uid58377 |
| 1483 | 2.677 | 4.494 | *Candidatus* Cloacamonas acidaminovorans\_Evry |
| 1383.1 | 2.276 | 4.513 | *Rhizobium etli*\_CIAT\_652\_uid59115 |
| 1402.4 | 2.501 | 4.538 | *Rhizobium leguminosarum bv trifolii*\_WSM2304 |
| 1313.8 | 2.186 | 4.598 | *Arthrobacter aurescens*\_TC1\_uid58109 |
| 948.4 | 2.228 | 4.644 | Mycobacterium\_JDM601\_uid67369 |
| 1267 | 2.192 | 4.654 | *Spirochaeta smaragdinae*\_DSM\_11293\_uid51369 |
| 1059.1 | 2.175 | 4.669 | *Beutenbergia cavernae*\_DSM\_12333\_uid59047 |
| 1341.9 | 2.202 | 4.699 | Arthrobacter\_FB24\_uid58141 |
| 1430.8 | 2.614 | 4.767 | *Rhizobium leguminosarum bv trifolii*\_WSM1325 |
| 1074.7 | 2.277 | 4.830 | *Mycobacterium avium paratuberculosis*\_K\_10 |
| 1328.2 | 2.229 | 4.972 | Agrobacterium\_H13\_3\_uid63403 |
| 1345 | 2.241 | 4.986 | Nocardioides\_JS614\_uid58149 |
| 1331.3 | 2.247 | 5.010 | *Agrobacterium vitis*\_S4\_uid58249 |
| 1278 | 2.244 | 5.043 | *Rhodococcus equi*\_103S\_uid60171 |
| 1452 | 2.685 | 5.057 | *Rhizobium leguminosarum bv viciae*\_3841 |
| 1211.8 | 2.293 | 5.067 | *Mycobacterium abscessus*\_uid61613 |
| 1368.9 | 2.274 | 5.200 | Polaromonas\_JS666\_uid58207 |
| 1277.9 | 2.287 | 5.288 | *Bordetella petrii*\_uid61631 |
| 1268 | 2.334 | 5.339 | *Bordetella bronchiseptica*\_RB50\_uid57613 |
| 710.1 | 1.621 | 5.355 | *Nostoc azollae*\_\_0708\_uid49725 |
| 1284.3 | 2.468 | 5.382 | *Sphingomonas wittichii*\_RW1\_uid58691 |
| 1074.9 | 2.495 | 5.475 | *Mycobacterium avium*\_104\_uid57693 |
| 1275.8 | 2.399 | 5.548 | *Mycobacterium gilvum*\_Spyr1\_uid61403 |
| 1112.2 | 2.365 | 5.567 | *Verminephrobacter eiseniae*\_EF01\_2\_uid58675 |
| 1303.6 | 2.491 | 5.620 | *Mycobacterium gilvum*\_PYR\_GCK\_uid59421 |
| 1306.9 | 2.483 | 5.705 | Mycobacterium\_MCS\_uid58465 |
| 1320.9 | 2.567 | 5.737 | Mycobacterium\_KMS\_uid58491 |
| 1319.4 | 2.582 | 6.048 | Mycobacterium\_JLS\_uid58489 |
| 1469.2 | 2.681 | 6.177 | *Burkholderia phymatum*\_STM815\_uid58699 |
| 860.6 | 1.827 | 6.196 | *Pirellula staleyi*\_DSM\_6068\_uid43209 |
| 1465.6 | 2.866 | 6.283 | *Streptomyces cattleya*\_NRRL\_8057\_DSM\_46488 |
| 1402.8 | 2.761 | 6.359 | *Conexibacter woesei*\_DSM\_14684\_uid43467 |
| 1435.8 | 2.700 | 6.516 | *Rhodococcus erythropolis*\_PR4\_uid59019 |
| 1471 | 2.940 | 6.558 | *Cupriavidus necator*\_N\_1\_uid68689 |
| 1436.7 | 2.707 | 6.656 | *Agrobacterium radiobacter*\_K84\_uid58269 |
| 1449.2 | 2.938 | 6.988 | *Mycobacterium smegmatis*\_MC2\_155\_uid57701 |
| 1403.9 | 2.779 | 7.013 | *Achromobacter xylosoxidans*\_A8\_uid59899 |
| 1464.6 | 2.952 | 7.097 | *Pseudonocardia dioxanivorans*\_CB1190 |
| 1341.4 | 2.024 | 7.215 | *Hahella chejuensis*\_KCTC\_2396\_uid58483 |
| 1057.6 | 1.961 | 7.750 | *Trichodesmium erythraeum*\_IMS101\_uid57925 |
| 1478.2 | 3.435 | 7.805 | *Rhodococcus jostii*\_RHA1\_uid58325 |
| 1474.4 | 3.344 | 7.913 | *Rhodococcus opacus*\_B4\_uid13791 |
| 1422.8 | 3.113 | 8.816 | *Frankia EuI* 1c\_uid42615 |
| 1411 | 2.370 | 9.004 | *Myxococcus fulvus*\_HW\_1\_uid68443 |
| 1319.3 | 2.349 | 9.446 | *Haliangium ochraceum*\_DSM\_14365\_uid41425 |
| 1477.8 | 3.463 | 10.237 | *Amycolatopsis mediterranei*\_U32\_uid50565 |

1 p.i.—paralog index, *Rank*—is an averaged rank calculated for multiple runs of theS-ranking procedure. Genomes are sorted by ascending size of genome for easier comparison with Figure 2.

**Table S2.** Complete list of atypical genomes according to *S-Rank*.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Rank** | **Size** | **Atypical Genomes** | **K** |  |
| 622.8 | 1.591 | *Candidatus* Korarchaeum cryptofilum\_OPF8 | A | Crenarchaeota |
| 791.4 | 1.782 | *Thermofilum pendens*\_Hrk\_5\_uid58563 | A | Crenarchaeota |
| 792.6 | 1.842 | *Thermoproteus tenax*\_Kra\_1\_uid74443 | A | Crenarchaeota |
| 808.9 | 1.846 | *Thermococcus sibiricus*\_MM\_739\_uid59399 | A |  |
| 754.3 | 1.908 | *Pyrococcus furiosus*\_DSM\_3638\_uid57873 | A |  |
| 804.9 | 1.936 | *Thermoproteus uzoniensis*\_768\_20\_uid65089 | A | Crenarchaeota |
| 803.4 | 2.001 | *Halobacterium salinarum*\_R1\_uid61571 | A |  |
| 792.7 | 2.010 | *Thermococcus barophilus*\_MP\_uid54733 | A |  |
| 790.5 | 2.011 | Thermococcus\_4557\_uid70841 | A |  |
| 811.5 | 2.014 | Halobacterium\_NRC\_1\_uid57769 | A |  |
| 753.2 | 2.045 | *Thermococcus gammatolerans*\_EJ3\_uid59389 | A |  |
| 875.7 | 2.046 | *Ilyobacter polytropus*\_DSM\_2926\_uid59769 | B |  |
| 797.8 | 2.121 | *Pyrobaculum arsenaticum*\_DSM\_13514\_uid58409 | A |  |
| 38.3 | 2.127 | *Orientia tsutsugamushi\_*Boryong\_uid61621 | B |  |
| 836.2 | 2.192 | *Metallosphaera sedula*\_DSM\_5348\_uid58717 | A | Crenarchaeota |
| 1225.1 | 2.809 | *Halalkalicoccus jeotgali*\_B3\_uid50305 | A |  |
| 1233.4 | 2.821 | *Halogeometricum borinquense*\_DSM\_11551 | A |  |
| 1235.3 | 2.848 | *Haloferax volcanii*\_DS2\_uid46845 | A |  |
| 1091.1 | 2.914 | *Halophilic archaeon*\_DL31\_uid72619 | A |  |
| 1131.5 | 2.992 | *Sulfolobus solfataricus*\_P2\_uid57721 | A |  |
| 1133.9 | 3.218 | *Rhodobacter sphaeroides*\_ATCC\_17025\_uid58451 | B |  |
| 1186.8 | 3.261 | *Halorubrum lacusprofundi*\_ATCC\_49239\_uid58807 | A |  |
| 206.9 | 3.268 | *Mycobacterium leprae*\_Br4923\_uid59293 | B |  |
| 207.5 | 3.268 | *Mycobacterium leprae*\_TN\_uid57697 | B |  |
| 1417.6 | 3.311 | Azospirillum\_B510\_uid46085 | B |  |
| 1240.8 | 3.420 | *Haloarcula marismortui*\_ATCC\_43049\_uid57719 | A |  |
| 1235 | 3.484 | *Haloarcula hispanica*\_ATCC\_33960\_uid72475 | A |  |
| 1236.4 | 3.521 | *Ralstonia solanacearum*\_PSI07\_uid50539 | B |  |
| 1426.9 | 3.654 | *Sinorhizobium meliloti*\_1021\_uid57603 | B |  |
| 1306.5 | 3.668 | *Halopiger xanaduensis*\_SH\_6\_uid68105 | A |  |
| 1239 | 3.716 | *Ralstonia solanacearum*\_GMI1000\_uid57593 | B |  |
| 1260.9 | 3.752 | *Natrialba magadii*\_ATCC\_43099\_uid46245 | A |  |
| 504.6 | 3.769 | *Xanthomonas albilineans*\_GPE\_PC73\_uid43163 | B |  |
| 1401.9 | 3.782 | *Sinorhizobium medicae*\_WSM419\_uid58549 | B |  |
| 1419.5 | 3.889 | *Haloterrigena turkmenica*\_DSM\_5511\_uid43501 | A |  |
| 1425.8 | 3.926 | Rhizobium\_NGR234\_uid59081 | B |  |
| 1403.3 | 3.928 | *Cupriavidus metallidurans*\_CH34\_uid57815 | B |  |
| 385.4 | 4.171 | *Sodalis glossinidius morsitans*\_\_uid58553 | B |  |
| 1399.1 | 4.382 | Rhizobium\_etli\_CFN\_42\_uid58377 | B |  |
| 1483 | 4.494 | *Candidatus*\_Cloacamonas\_acidaminovorans\_Evry | B |  |
| 666.6 | 4.627 | *Leptospira interrogans serovar*\_Copenhageni\_Fiocruz | B |  |
| 769.9 | 4.970 | *Shewanella oneidensis*\_MR\_1\_uid57949 | B |  |
| 710.1 | 5.355 | *Nostoc azollae*\_\_0708\_uid49725 | B |  |
| 852.8 | 5.473 | *Isosphaera pallida*\_ATCC\_43644\_uid62207 | B |  |
| 860.6 | 6.196 | *Pirellula staleyi*\_DSM\_6068\_uid43209 | B |  |
| 1057.6 | 7.750 | *Trichodesmium erythraeum*\_IMS101\_uid57925 | B |  |

**Table S3.** Paralogization indices of Shigella.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***Rank*** | ***Ave*** | ***Size*** | ***p.i.*** | ***mp*** | **Genome** |
| 893.2 | 1.80 | 4.6 | 0.26 | 0.43 | *Shigella boydii* CDC 3083 |
| 875.9 | 1.82 | 4.5 | 0.26 | 0.42 | *Shigella boydii* Sb227 |
| 879.9 | 1.90 | 4.4 | 0.25 | 0.39 | *Shigella dysenteriae* |
| 981.2 | 1.82 | 4.6 | 0.28 | 0.43 | *Shigella flexneri* 2a 2457T |
| 983.4 | 1.86 | 4.6 | 0.26 | 0.41 | *Shigella flexneri* 2a 301 |
| 981.2 | 1.79 | 4.6 | 0.28 | 0.43 | *Shigella flexneri* 5 8401 |
| 1008.1 | 1.88 | 4.8 | 0.28 | 0.43 | *Shigella sonnei* |

**Table S4.** Taxonomy of outliers.

|  |  |
| --- | --- |
| **Figure 1** | |
| Taxa | Occurrence |
| Aliivibrio | 1 |
| Brucella | 1 |
| Candidatus | 1 |
| Ehrlichia | 1 |
| Mycobacterium | 2 |
| Orientia | 1 |
| Prevotella | 1 |
| Sodalis | 1 |
| Treponema | 1 |
| Vibrio | 6 |

|  |  |  |  |
| --- | --- | --- | --- |
| **Figure 2** | | | |
| Taxa | Occurrence | Taxa | Occurrence |
| Nostoc | 1 | Orientia | 1 |
| Achromobacter | 1 | Pantoea | 1 |
| Agrobacterium | 3 | Pirellula | 1 |
| Amycolatopsis | 1 | Polaromonas | 1 |
| Arthrobacter | 2 | Pseudonocardia | 1 |
| Azospirillum | 1 | Renibacterium | 1 |
| Beutenbergia | 1 | Rhizobium | 6 |
| Bordetella | 2 | Rhodococcus | 4 |
| Burkholderia | 1 | Sinorhizobium | 2 |
| Candidatus | 1 | Sodalis | 1 |
| Conexibacter | 1 | Sphingomonas | 1 |
| Cupriavidus | 2 | Spirochaeta | 1 |
| Frankia | 1 | Streptomyces | 1 |
| Hahella | 1 | Sulfolobus | 1 |
| Halobacteriaceae | 9 | Trichodesmium | 1 |
| Mycobacteriaceae | 10 | Verminephrobacter | 1 |
| Myxococcus | 1 |  |  |
| Nocardioides | 1 |  |  |
| Novosphingobium | 1 |  |  |
| Phytoplasma | 1 |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| **Figure 3** | | | |
| Taxa | Occurrence | Taxa | Occurrence |
| Nostoc | 1 | Pirellula | 1 |
| Azospirillum | 1 | Ralstonia | 2 |
| Candidatus Cloacamonas | 1 | Rhizobium | 2 |
| Candidatus Korarchaeum | 1 | Rhodobacter | 1 |
| Cupriavidus | 1 | Shewanella | 1 |
| Halobacteriaceae | 12 | Sinorhizobium | 2 |
| Ilyobacter | 1 | Sodalis | 1 |
| Isosphaera | 1 | Sulfolobus | 1 |
| Leptospira | 1 | Thermococcaceae | 5 |
| Metallosphaera | 1 | Thermofilum | 1 |
| Mycobacterium leprae | 2 | Trichodesmium | 1 |
| Orientia | 1 | Xanthomonas | 1 |

|  |  |
| --- | --- |
| **Figure 4** | |
| Taxa | Occurrence |
| *Candidatus* cloacamonas | 1 |
| *Candidatus* Ruthia | 1 |
| Gardnerella | 1 |
| Haemophilus | 1 |
| Mycoplasmataceae | 8 |
| Neisseria | 5 |
| Phytoplasmas | 6 |
| Staphylothermus | 1 |
| Streptococcus | 1 |
| Sulfolobus | 2 |
| Thermosphaera | 1 |
| Treponema | 1 |

**Table S6.** Orientia tsutsugamushi and Rickettsias.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Rank*** | ***Ave*** | **Genome Size** | **# of Genes** | ***p.i.*** | ***mp*** | **Strain** |
| 38.3 | 1.4 | 2.1 | 1182 | 0.09 | 0.36 | *Orientia tsutsugamushi* Boryong |
| 66.8 | 1.8 | 2.0 | 1967 | 0.12 | 0.42 | *Orientia tsutsugamushi* Ikeda |
| 60.2 | 1.2 | 1.2 | 1257 | 0.11 | 0.22 | *Rickettsia akari* Hartford |
| 81.1 | 1.3 | 1.5 | 1475 | 0.13 | 0.34 | *Rickettsia bellii* OSU |
| 103.8 | 1.3 | 1.5 | 1429 | 0.16 | 0.29 | *Rickettsia bellii* RML369 |
| 40.6 | 1.1 | 1.2 | 1089 | 0.09 | 0.21 | *Rickettsia canadensis* McKiel |
| 101.1 | 1.2 | 1.3 | 1374 | 0.14 | 0.25 | *Rickettsia conorii* Malish |
| 124.2 | 1.4 | 1.5 | 1400 | 0.16 | 0.31 | *Rickettsia felis* |
| 63.1 | 1.2 | 1.3 | 1297 | 0.11 | 0.21 | *Rickettsia heilongjiangensis* |
| 67 | 1.1 | 1.3 | 971 | 0.10 | 0.21 | *Rickettsia japonica* |
| 67.9 | 1.2 | 1.4 | 968 | 0.10 | 0.25 | *Rickettsia massiliae* |
| 66.3 | 1.2 | 1.3 | 927 | 0.09 | 0.21 | *Rickettsia peacockii* Rustic |
| 60.2 | 1.1 | 1.1 | 843 | 0.09 | 0.22 | *Rickettsia prowazekii* Madrid *E* |
| 58.7 | 1.2 | 1.3 | 1343 | 0.11 | 0.21 | *Rickettsia rickettsii* SheilaSmith |
| 68.5 | 1.2 | 1.3 | 1382 | 0.12 | 0.22 | *Rickettsia rickettsii* Iowa |
| 56.8 | 1.1 | 1.1 | 837 | 0.09 | 0.21 | *Rickettsia typhi* Wilmington |