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The social dimension of microbial niches

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1 **Microbial ecology:** The social dimension of microbial niches

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10 **Standfirst:** For long, the ecological niche concept was less popular for microbes than for other
11 organisms. A new proxy of a microorganisms's ecological niche breadth, based on the variability of
12 the communities it associates with, allows interrogation of the correlates of being a social generalist
13 or social specialist.

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16 **Main text:**

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18 Species vary in the range of abiotic and biotic conditions that they can cope with; generalist species
19 can thrive in a variety of habitats or situations, while specialists are restricted to a smaller set of
20 conditions. Microbes vary on this continuum as well, with generalists (e.g. most of our heavily
21 studied cultivable model bacteria) having a wider ecological niche and specialists like strict
22 endosymbiotic bacteria, having a narrower one¹. Defining an organism's niche requires a solid
23 understanding of the conditions in which it persists. This is hard enough for larger and better-studied
24 organisms, and feels nearly impossible for the microbial world, for which micrometre scale conditions
25 and interactions matter. Fortunately, the era of DNA sequencing derived from environmental samples
26 has changed the game – so what can we learn about microbial niches from the thousands of available
27 datasets? Writing in *Nature Ecology & Evolution*, Von Meijenfeldt et al² define one aspect of the
28 microbial niche, the “social niche”, reflecting how much is constrained the community of other
29 microbes the species is observed with in environmental samples.

30 Some microbial species occur in a variety of compositionally dissimilar communities, while some
31 other always share their surroundings with a consistent suite of other microorganisms. The authors
32 classified over 20'700 microbial taxa from all ranks along a gradient based on their Social Niche
33 Breadth (SNB) and examined genomic correlates of being a social specialist versus a social generalist
34 species. The SNB is defined as the mean of the pairwise compositional dissimilarity between the
35 samples in which a taxon is found (Fig. 1). The rationale for using the SNB score as a proxy of
36 ecological niche breadth is that the broader are the environmental conditions a species can cope
37 with, the more likely it is to share its habitat with a wide array of other species. This thinking has
38 already been used for plants and animals^{3,4}.

39 Von Meijenfeldt et al² computed SNB scores for every known prokaryote taxon from over 22
40 thousand published environmental samples. Importantly, the SNB score can be calculated at any

41 taxonomical rank level, from phylum to species; this taxonomic distinction allows them to show that
42 higher taxonomic levels that are social generalists can contain subtaxa that include either social
43 generalists or specialists. For example, the family *Flavobacteriaceae* is a social generalist, but the
44 clade contains daughter taxa that are mostly social specialist genera. On the other hand, the social
45 generalist *Lactobacillaceae* contains many social generalist genera. This suggests numerous and
46 independent social specialization or niche range expansion throughout evolution.

47 The study also explores the various ecological properties of being a microbial social generalist or a
48 social specialist. Notably, social specialists have a relatively even abundance across samples in which
49 they appear, whereas social generalists tend to locally dominate the communities but with a more
50 variable relative abundance across samples. This result supports the hypothesis that social specialists
51 have a low but constant abundance near carrying capacity (K-selected), and some social generalists
52 are opportunistic taxa that reach high relative abundance when circumstances permit (r-selected)^{5,6}.

53 Secondly, the SNB score was correlated with genomic properties, such as genome size and additional
54 related features (i.e., the number of nucleotides, of genes, or of unique functions, as well as genome
55 size variation within the genus, pan-genome size and openness). Indeed, a number of recent studies
56 support the theoretical association between genome size and niche breadth, with ecological generalists
57 having larger genome to adapt to diverse conditions and specialists having reduced genome due the
58 loss of unnecessary genes⁷. Here, the authors found no direct correlation between genome size and
59 SNB score, but the genomes of social generalists were found to be more variable in size than the
60 genomes of social specialists that encode for a smaller and more closed pan-genome. These
61 properties point to an increased genomic fluidity of social generalists, as confirmed by their
62 enrichment in invasive mobile elements (plasmids, phages), highlighting a possible mechanism by
63 which social generalists keep open pan-genomes.

64 In addition, social specialists are overall enriched in fewer gene categories than social generalists.
65 This is because the functional genes kept during specialization depend on the conditions encounter
66 by the taxon. The analysis also demonstrates different properties of social specialists typically found
67 in communities of low or high biodiversity, with high-diversity specialists having more enriched
68 functions. Overall, the authors suggest that social specialization comes in many forms in the
69 microbial world.

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71 Future work will need to test how SNB scores compare to other niche breadth metrics (e.g. based on
72 genomics⁸). How much will the metric be adopted. and contributory to the scientific community –
73 being either “specialists” research groups focused on specific taxa or habitats, or “generalists” driven by
74 general questions in microbial ecology? Most importantly, one can look forward to seeing how the SNB
75 score will improve ecosystem fate predictions⁹ by understanding ecological properties (e.g. invasion
76 and colonization capacity, ecological relationships such as competition or mutualism, resistance and
77 resilience to perturbations, etc) of studied taxa or communities in order to promote our overall
78 understanding of microbial ecology.

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80 **Competing Interests**

81 The author declares no competing interests.

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83 **References**

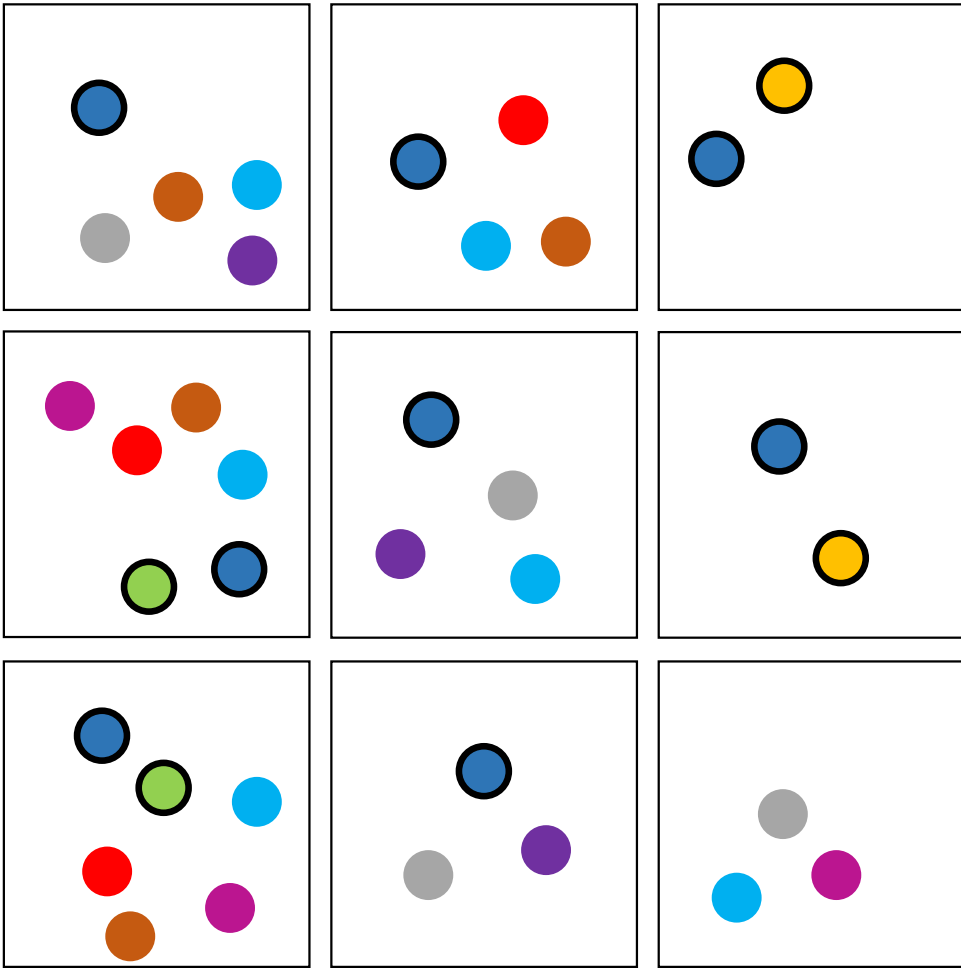
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104 Figure 1. **Community composition similarity as a quantitative ecological feature of the microbial**
105 **« social niche »**. The graphic is a simplified depiction of how von Meijenfeldt et al² determined
106 microbes' Social Niche Breadth (SNB). The squares represent independent environmental samples
107 (from published datasets), comprised of several microbial taxa depicted as colored circles. The dark
108 blue microbe occurs in compositionally very dissimilar communities across the different samples; its
109 SNB score would be high and thus considered a social generalist. The yellow microbe always occurs
110 with the same dark blue taxon; its SNB score would be low and it should be considered a social
111 specialist. Social specialists can be found in either low-diversity samples, like the yellow microbe, or in
112 high-diversity samples, like the green microbe, which is always found in samples with the same
113 composition.



- Environmental sample
- A microbial taxon
- A low-diversity social specialist
- A high-diversity social specialist
- A social generalist

Biodiversity