



Universidade de São Paulo
Instituto de Química



Microbiomes in the São Paulo Zoo

João Carlos Setubal

2022

Since 2000, the main new topic
(for me)
has been

metagenomics-microbiomics

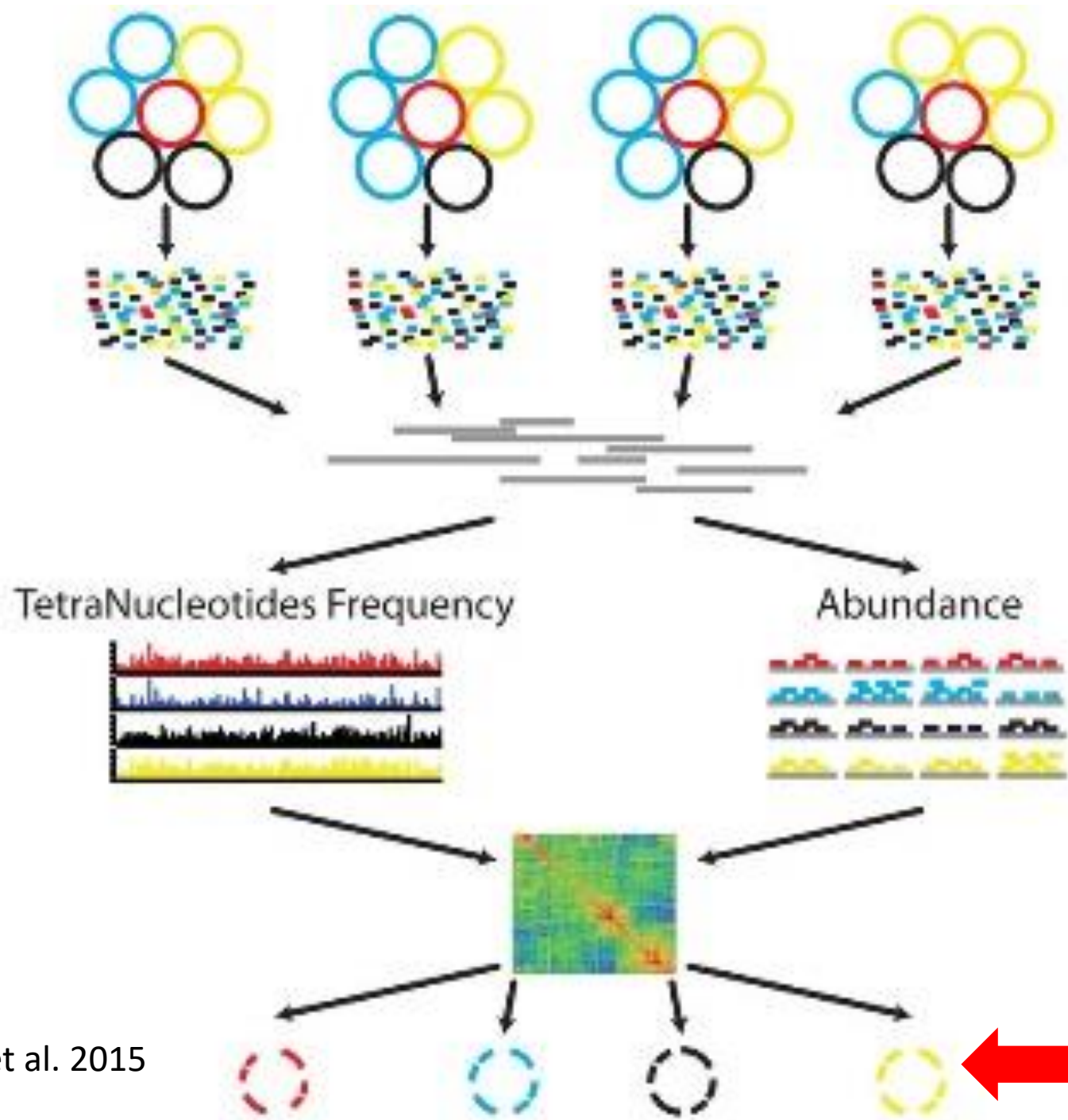
A few definitions

- **Microbiota**: microbial community in a given environment
- **Metagenome**: the result of metagenomic sequencing (no isolation) of a sample
- **Microbiome**: genomes + gene sequences + gene product sequences identifiable in a metagenome

Targeted and total DNA (shotgun) sequencing

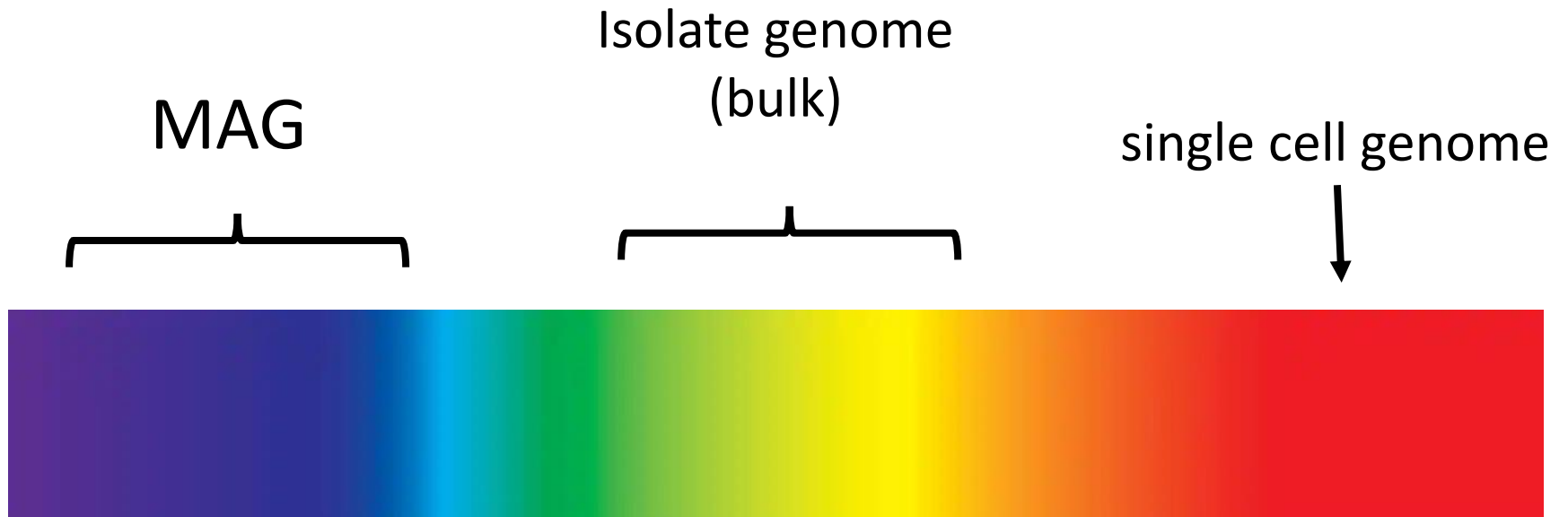
- Amplicon (targeted)
 - 16S (prokaryotes)
 - ITS (eukaryotes)
 - Species identification is **difficult or impossible**
 - **“metataxonomics”**
- total DNA (shotgun)
 - Access to the microbiome
 - Species and even strain identification is possible

Metagenome-Assembled Genome (MAG)



Kang et al. 2015

MAGs are at the left end of a contamination spectrum



The MAG explosion

nature
microbiology

ARTICLES

DOI: 10.1038/s41564-017-0012-7

OPEN

Recovery of nearly 8,000 metagenome-assembled genomes substantially expands the tree of life

Donovan H. Parks¹, Christian Rinke¹, Maria Chuvpochina, Pierre-Alain Chaumeil, Ben J. Woodcroft, Paul N. Evans, Philip Hugenholtz^{1*} and Gene W. Tyson^{1*}



Article

<https://doi.org/10.1038/s41467-022-32805-z>

A compendium of 32,277 metagenome-assembled genomes and over 80 million genes from the early-life human gut microbiome

A Catalog of over 5,000
Genomes from the Capri

Received: 16 February 2022

Shuqin Zeng¹, Dhriti Patangia^{2,3,4}, Alexandre Almeida^{5,6}, Zhemin Zhou⁷,
Dezhi Mu¹, R. Paul Ross^{2,4}, Catherine Stanton^{2,3} & Shaopu Wang¹✉

Accepted: 16 August 2022

¹Xiao-Xuan Zhang,^{a,b,h} Qing-Bo Lv,^{a,b,h} ²Qiu-Long Yan,^c Yue Zhang,^d Ruo-Chun Guo,^d Jin-Xin Meng,^a He Ma,^a Si-Yuan Qin,^{e,f} Qing-He Zhu,^{b,h} Chun-Qiu Li,^{b,h} Rui Liu,^a Gang Liu,^a Sheng-Hui Li,^{d,g} ³Dong-Bo Sun,^{b,h} ⁴Hong-Bo Ni^{a,h}

Projeto MetaZoo

Estudos da diversidade microbiana no Parque Zoológico
do Estado de São Paulo

(BIOTA/FAPESP: Microrganismos / Processo 2011/50870-6)



Coordenadores:

João Carlos Setubal, IQ/USP

Aline Maria da Silva, IQ/USP

2013-2018



Whose idea it was



Luiz Juliano Neto
Unifesp

- 2009
 - Professor Kohei Oda (U. Kyoto) visits the Zoo
 - “compost is a gold mine!”
 - LJN proposes Microbiology lab in the Zoo
 - FAPESP grant (2010-2012) to study composting (pilot)
- Thematic project was the successor of this pilot

Composting Unit at the São Paulo Zoo Park

Facility designed to compost 4 tons/day of all organic waste produced in the park: 44 concrete chambers of 1 m³



- Feces from ~ 400 species (3000 animals)
- Bedding materials and animal feed waste
- Plant debris from the park's Atlantic rain forest fragment and gardens
- Water treatment sludge

São Francisco Reservoir

Imagem: Acervo FPZSP



Aim: understand its microbiota seasonal variation

Howler monkey gut microbiome

Imagem: Acervo FPZSP






Carlos Nader/Acervo FPZSP

Compare the microbiomes of free-living and captive individuals

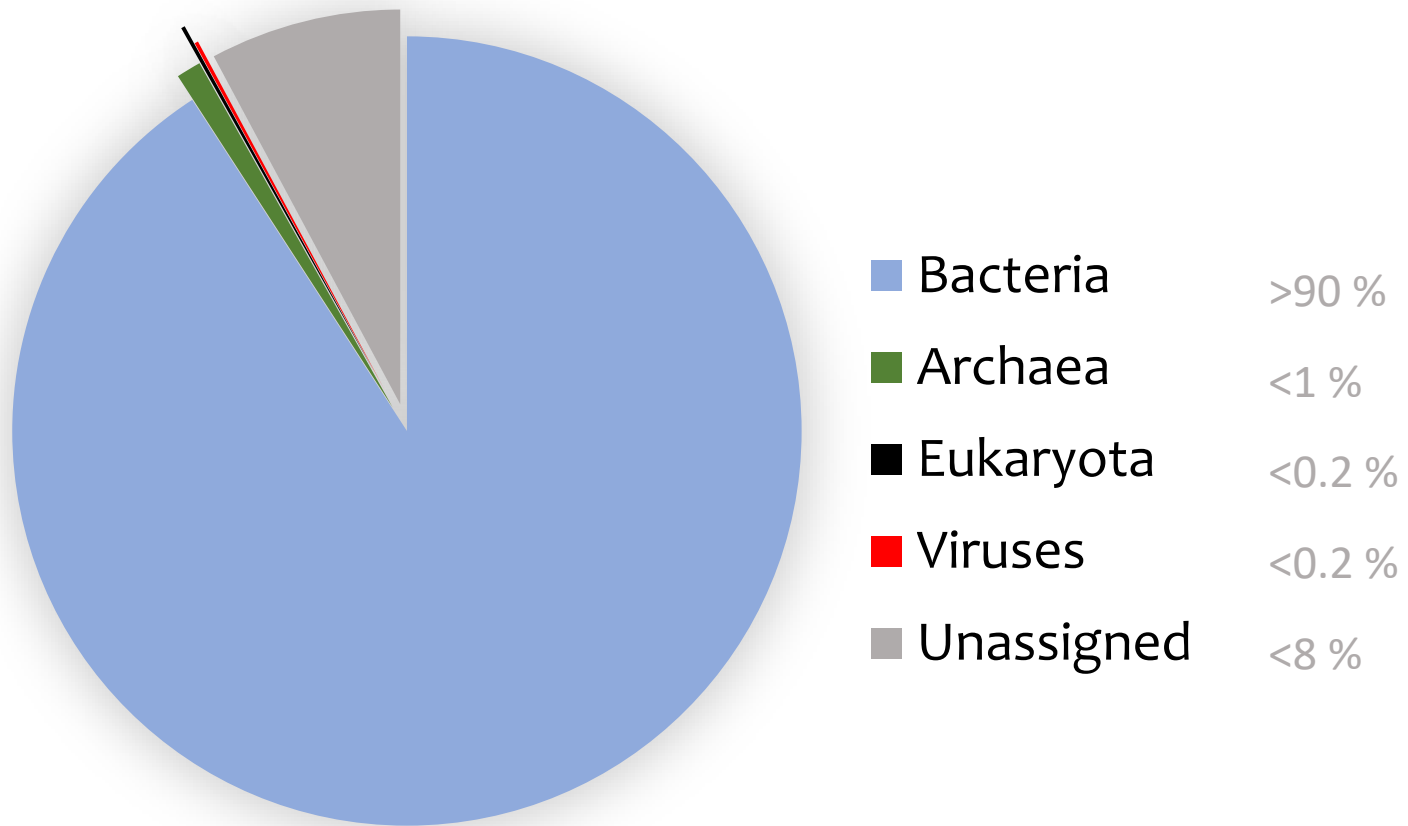
Composting: Pilot results (2013)

Metagenomic Analysis of a Tropical Composting Operation at the São Paulo Zoo Park Reveals Diversity of Biomass Degradation Functions and Organisms

Layla Farage Martins , Luciana Principal Antunes , Renata C. Pascon, Julio Cezar Franco de Oliveira, Luciano A. Digiampietri, Deibs Barbosa, Bruno Malveira Peixoto, Marcelo A. Vallim, Cristina Viana-Niero, Eric H. Ostroski, Guilherme P. Telles, Zandoni Dias, João Batista da Cruz, [...], João Carlos Setubal  [[view all](#)]

Published: April 24, 2013 • <https://doi.org/10.1371/journal.pone.0061928>

Bacteria are dominant



Unassembled shotgun reads from two independent Zoo
composting samples

Follow-up (2016)

SCIENTIFIC REPORTS



OPEN

Microbial community structure and dynamics in thermophilic composting viewed through metagenomics and metatranscriptomics

Received: 03 August 2016
Accepted: 14 November 2016
Published: 12 December 2016

Luciana Principal Antunes¹, Layla Farage Martins¹, Roberta Verciano Pereira¹, Andrew Maltez Thomas^{1,2}, Deibs Barbosa^{1,2}, Leandro Nascimento Lemos^{1,2}, Gianluca Major Machado Silva^{1,2}, Livia Maria Silva Moura^{1,2}, George Willian Condomitti Epamino^{1,2}, Luciano Antonio Digiampietri³, Karen Cristina Lombardi¹, Patricia Locosque Ramos⁴, Ronaldo Bento Quaggio¹, Julio Cezar Franco de Oliveira⁵, Renata Castiglioni Pascon⁵, João Batista da Cruz⁴, Aline Maria da Silva^{1,2,*} & João Carlos Setubal^{1,2,6,*}

Compost-derived consortium (2017)



Genome-Centric Analysis of a Thermophilic and Cellulolytic Bacterial Consortium Derived from Composting

OPEN ACCESS

Edited by:

Eric Afermann,

AgResearch, New Zealand

Reviewed by:

Dimitris Tsifas,

Cyprus University of Technology,

Leandro N. Lemos^{1,2}, *Roberta V. Pereira*¹, *Ronaldo B. Quaggio*¹, *Layla F. Martins*¹,
Livia M. S. Moura^{1,2}, *Amanda R. da Silva*^{1,2}, *Luciana P. Antunes*¹, *Aline M. da Silva*^{1††} and
João C. Setubal^{1,3††}

¹ Departamento de Bioquímica, Instituto de Química, Universidade de São Paulo, São Paulo, Brazil, ² Programa de Pós-Graduação Interunidades em Bioinformática, Universidade de São Paulo, São Paulo, Brazil, ³ Biocomplexity Institute, Virginia Tech, Blacksburg, VA, USA

Composting MAGs (2021)

Braga et al. *BMC Genomics* (2021) 22:652
<https://doi.org/10.1186/s12864-021-07957-9>

BMC Genomics

RESEARCH

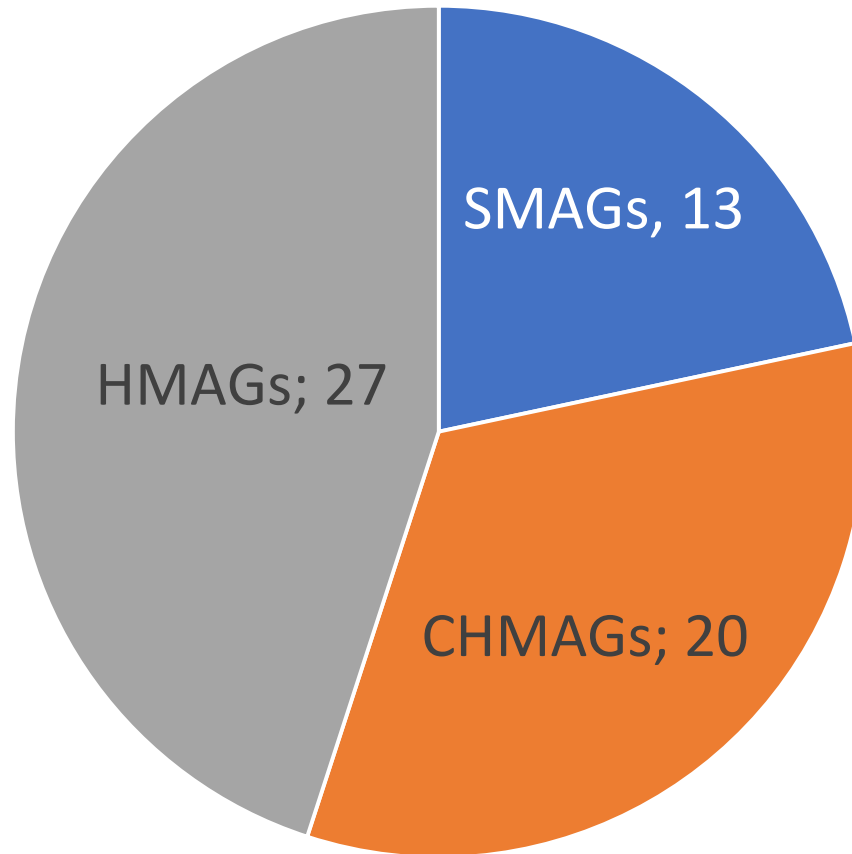
Open Access

Genome-resolved metagenome and metatranscriptome analyses of thermophilic composting reveal key bacterial players and their metabolic interactions

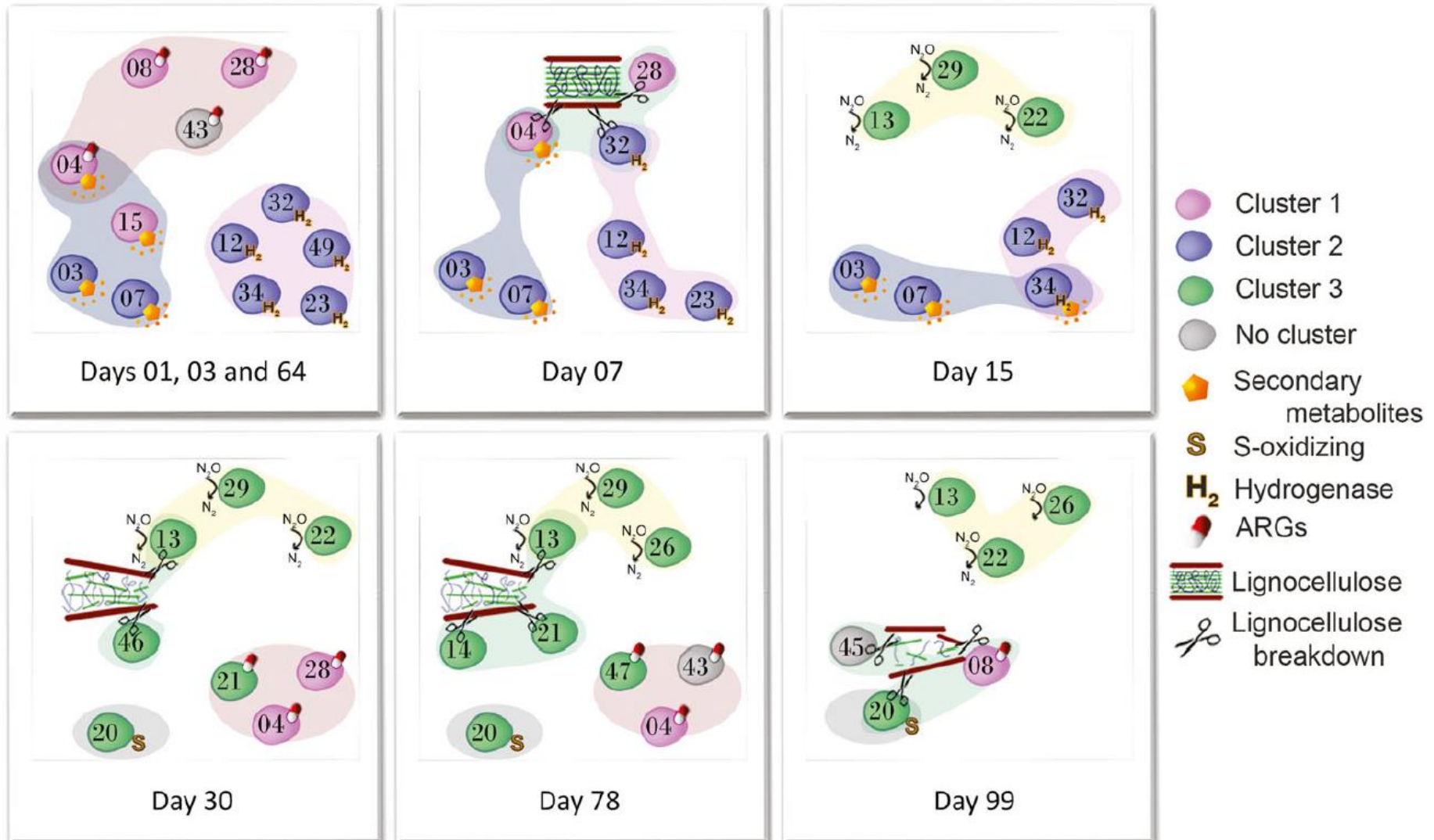


Lucas Palma Perez Braga^{1†}, Roberta Verciano Pereira^{1†}, Layla Farage Martins^{1†}, Livia Maria Silva Moura^{1,2†}, Fabio Beltrame Sanchez^{1,2}, José Salvatore Leister Patané³, Aline Maria da Silva^{1*} and João Carlos Setubal^{1*}

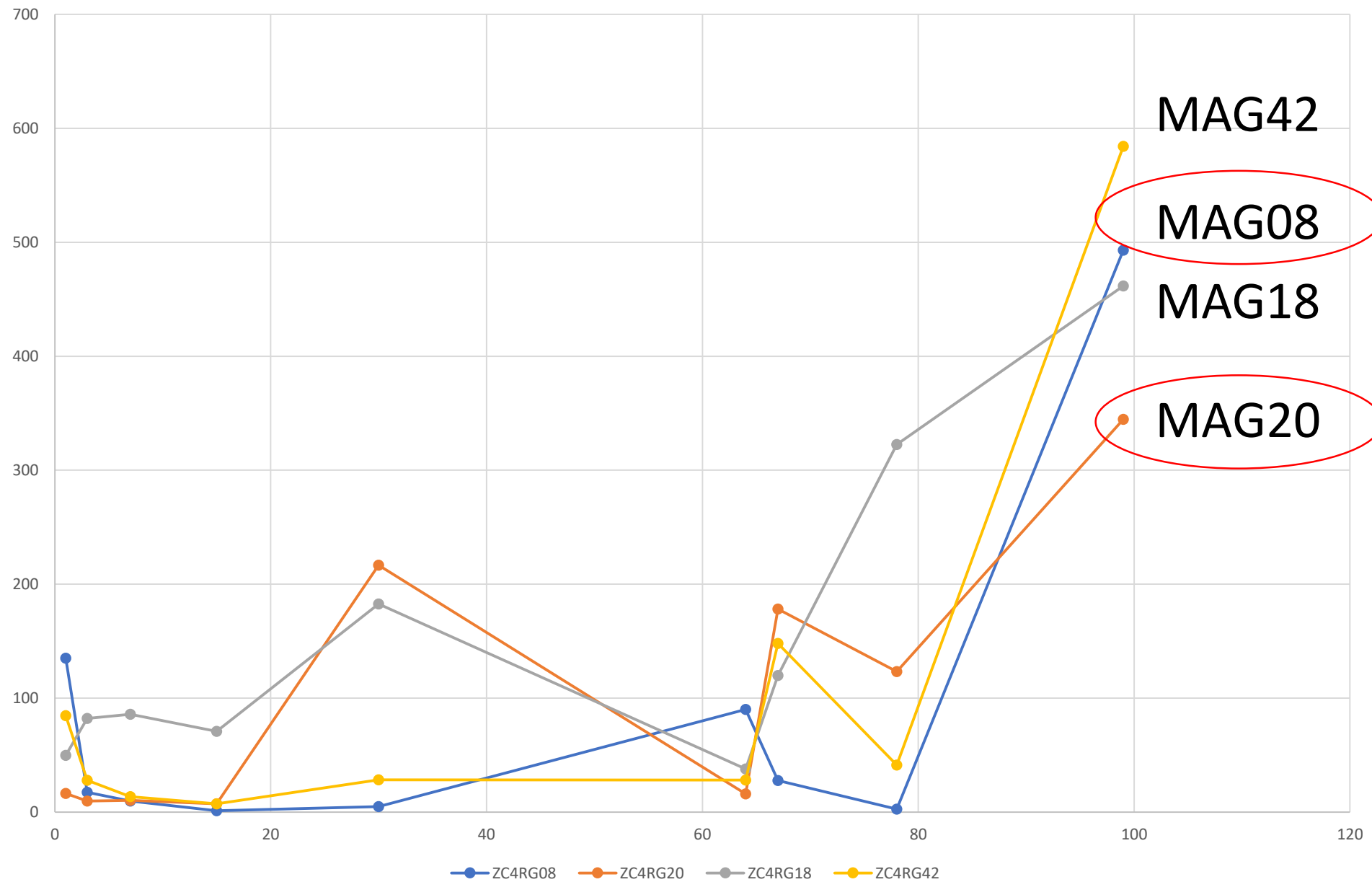
ZC4: 49 hq MAGs



The **dynamics** of composting based on MAGs & metatranscriptomics



increase at the end



MAG08 and MAG20 appear to be good lignin degraders

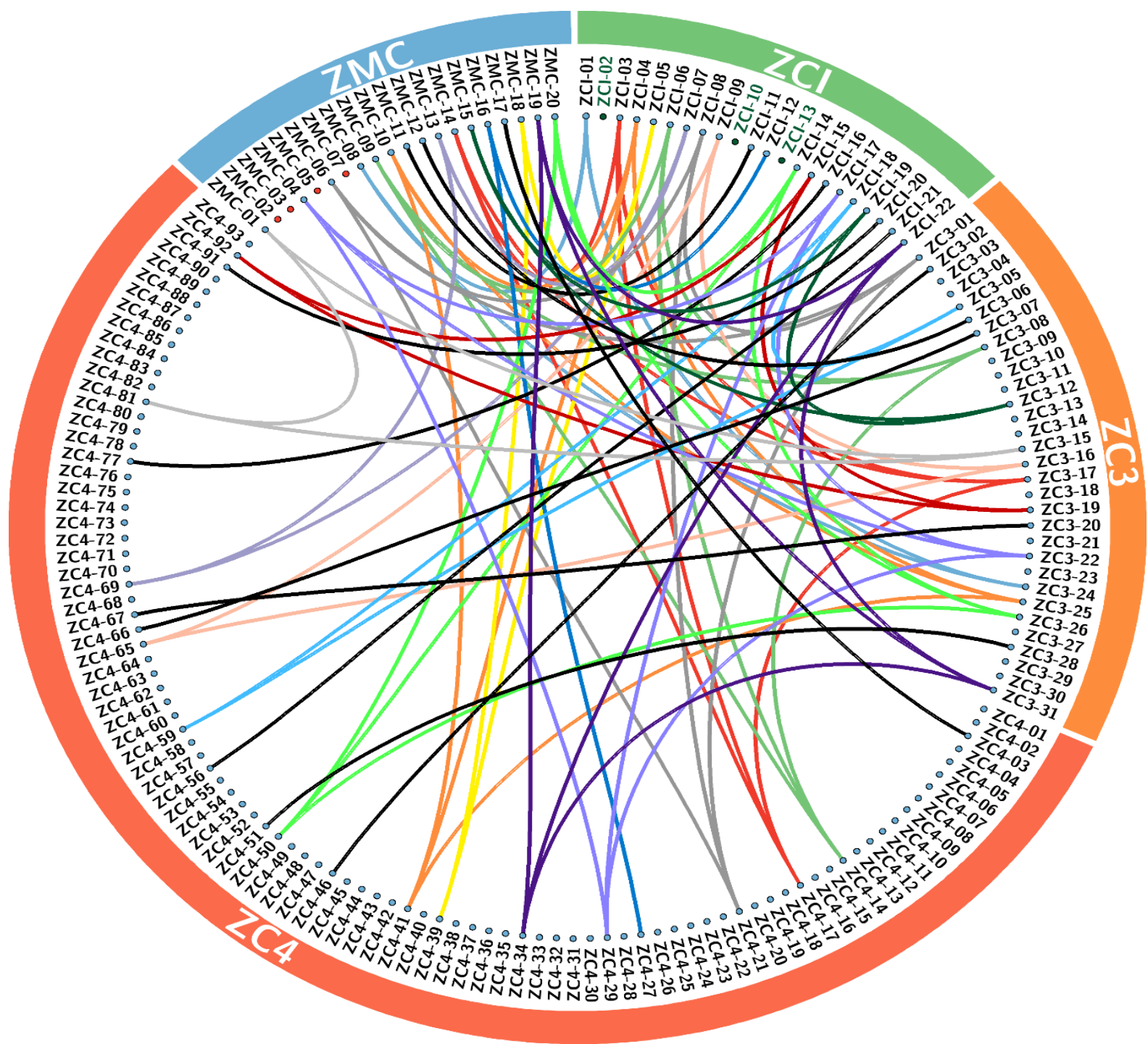
- Both have several genes for ligninolytic enzymes
- MAG08 – *Pseudomonas thermotolerans*
- MAG20 – A novel gammaproteobacterium

Still ongoing!

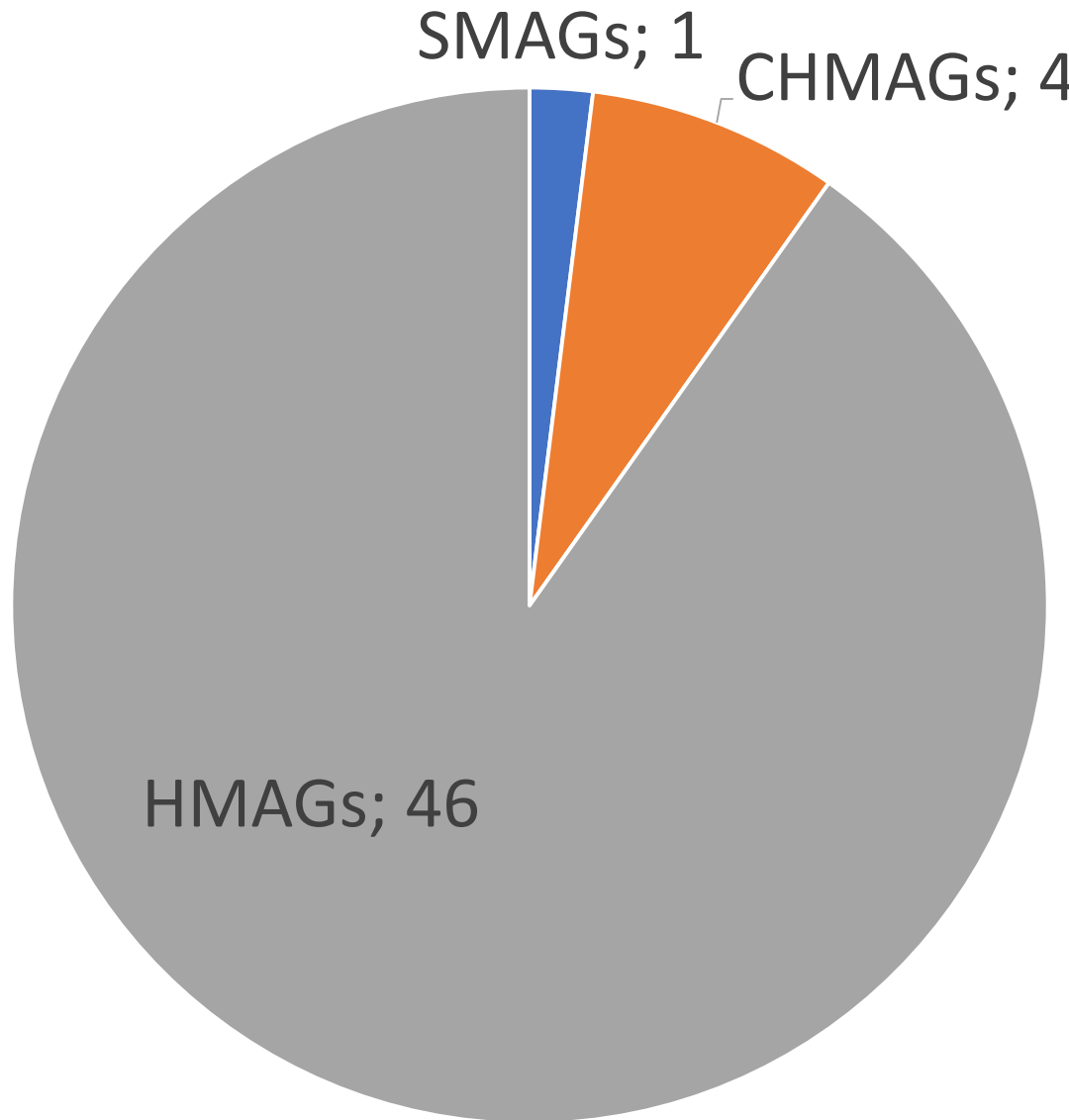
- New samples
 - Inocula
 - Mature compost
- More liberal MAG quality criteria
 - 50% completeness instead of 80%

Current MAG numbers

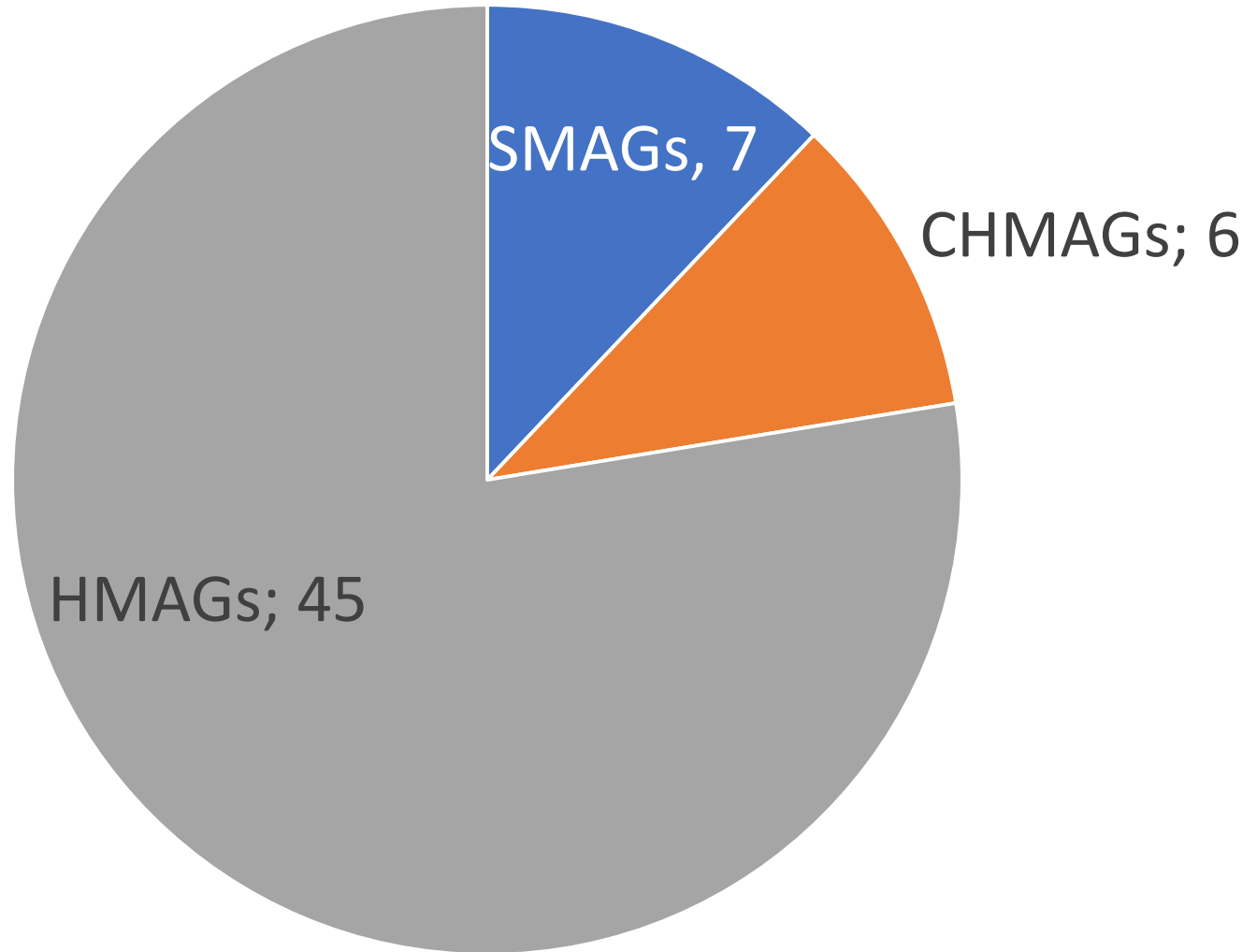
samples	# MAGs
ZC3	31
ZC4	93
inoculum	22
mature compost	20
total	166



São Francisco Reservoir: 51 hq MAGs



Howler monkeys: 58 hq MAGs



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- Paulo Bressan (FPZSP)

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Aline Maria da Silva



Layla Martins



Julio Oliveira

Deibs Barbosa
(reservoir)

Raquel Franco
(howler monkeys)

Suzana Guima
(composting)

Funding & Support



The background of the slide is a light gray field filled with various black and white line drawings of biological structures. These include various shapes of bacteria, some with flagella, several DNA double helix structures, and other cellular components like spores and viruses. The drawings are scattered across the entire page, creating a dense, scientific pattern.

Obrigado!

setubal@iq.usp.br