



**Sophia Escobar-Correas**

Postdoctoral Fellow |  
Brisbane

# Microbiome Dynamics and Waste Reduction Capabilities of Black Soldier Flies (*Hermetia illucens*) as Biosolid Consumers

*S. Escobar-Correas, A. Ruffell, G.  
Wijffels, **H. Koch**, A. Paten, M. Morgan*

Hauke Koch | CSIRO Environment  
Hauke.Koch@csiro.au

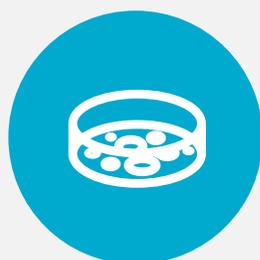
Australia's National Science Agency



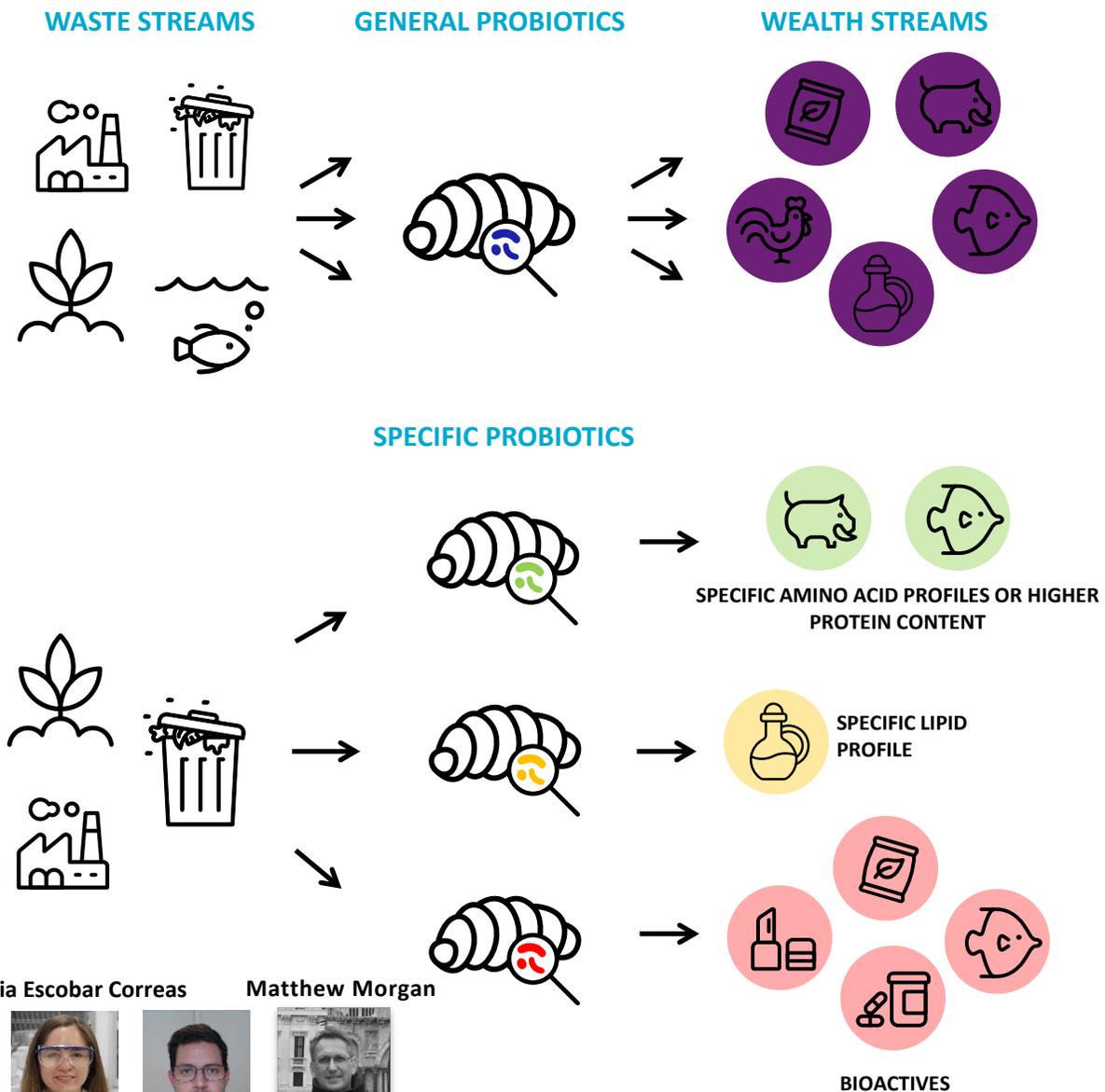


# Black Soldier Fly (BSF) Microbiome Team

- New multi-disciplinary team is designing and evolving new microbiomes that create value from the bioprocessing of different waste streams



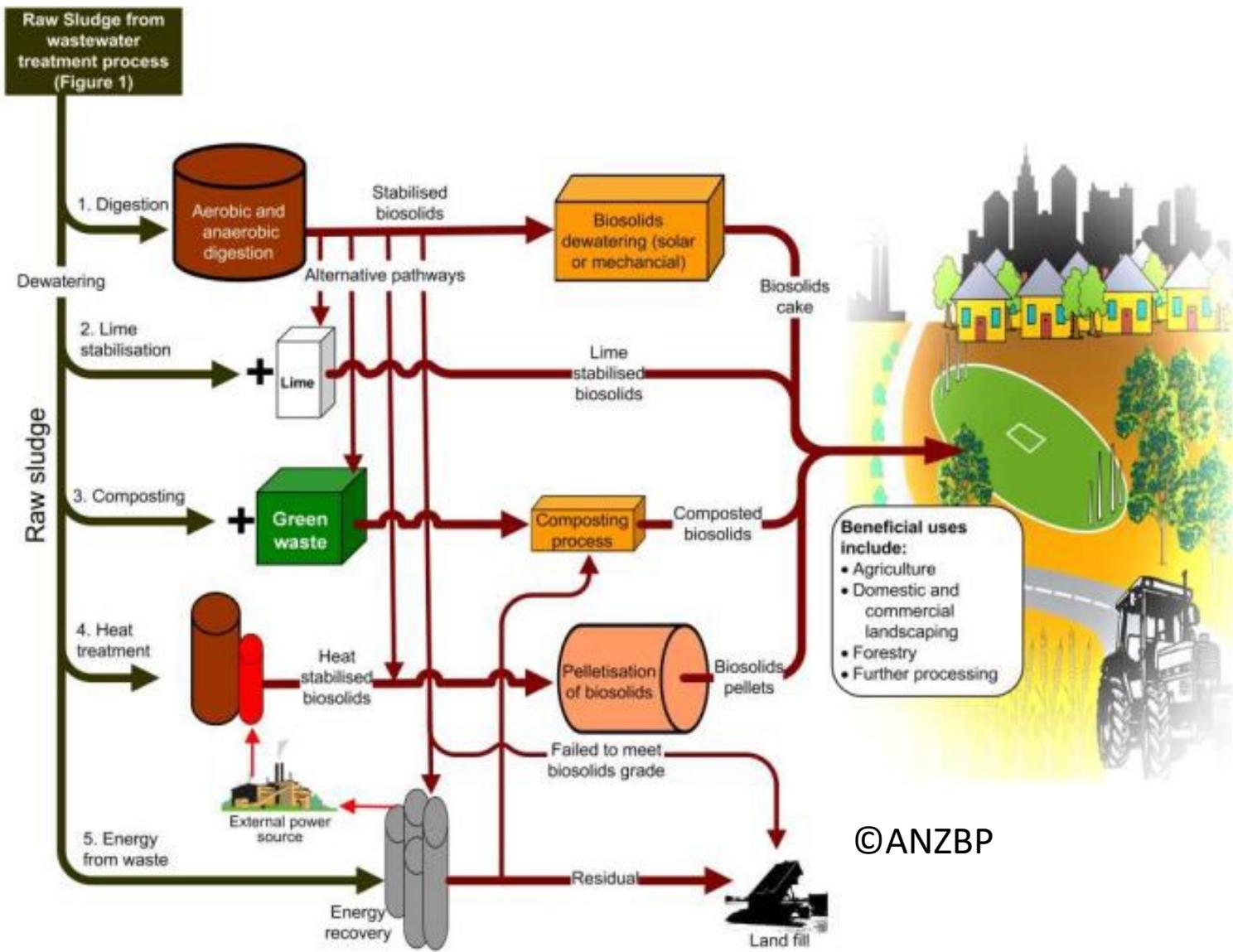
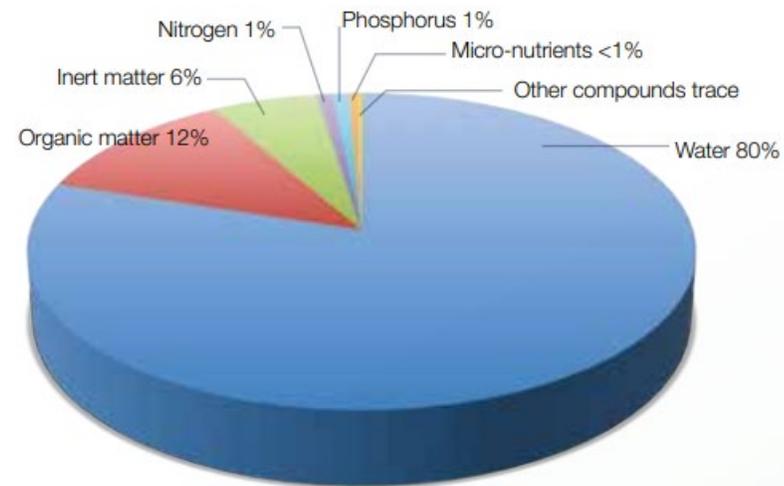
- In parallel, we are developing an inoculation method that is safe, scalable, and effective for industrial applications





# What are biosolids?

### Typical biosolids breakdown



©ANZBP



©Red58bill



# Biosolids: scale & contaminant problems

- 300,000 dry tonnes of biosolids produced annually in Australia, at a cost exceeding A\$310 million

Cost of biosolids treatment		
Treatment step	Cost per tonne processed (dry)	National annual cost
Dewatering	\$100-300	\$50 million
Stabilisation	\$300-1000	\$150 million
Storage	\$20-50	\$15 million
<b>Total treatment</b>	<b>\$400-1500</b>	<b>\$215 million</b>

- 2-3 million tons of sewage sludge yearly produced in the EU (European Commission SWD 2023)

The Guardian

## Legal action could end use of toxic sewage sludge on US crops as fertilizer

Intent to sue federal regulators charges they have failed to address dangerous levels of PFAS 'forever chemicals' known to be in sludge.

12 Mar 2024



CNN

## 'They told us that this material would be safe.' Toxic PFAS discovered on US farms

Farms across Maine are discovering toxic PFAS chemicals in their soil and water. But the problem could impact millions of acres of farmland...

2 May 2024



Sky News Australia

## Harmful levels of microplastics found in biosolid organic fertiliser

Concerned farmers and the Federal Opposition are calling for answers after biosolid organic fertiliser used on crops across Australia for...

1 June 2024



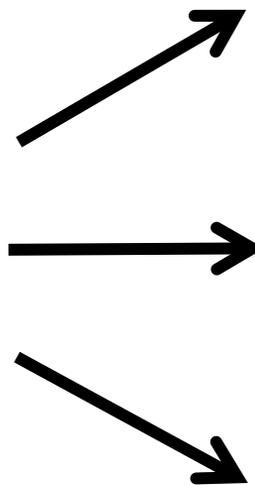
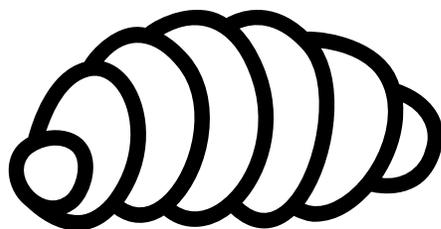


# Processing Biosolids with Black Soldier Fly Larvae (BSFL)



**BIOSOLIDS**

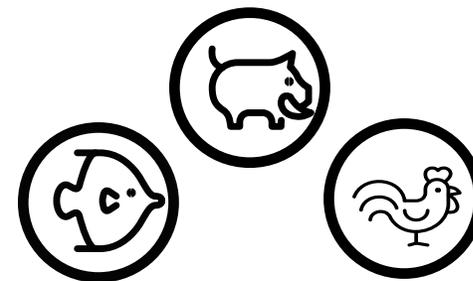
**BLACK SOLDIER FLY LARVAE**



**WASTE REDUCTION**



**ANIMAL FEED?**

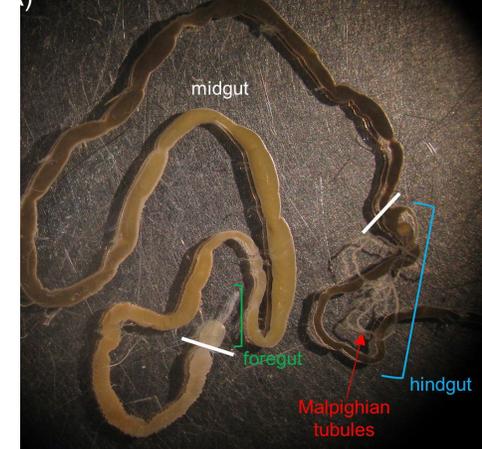


**FERTILIZER/BIOCHAR**

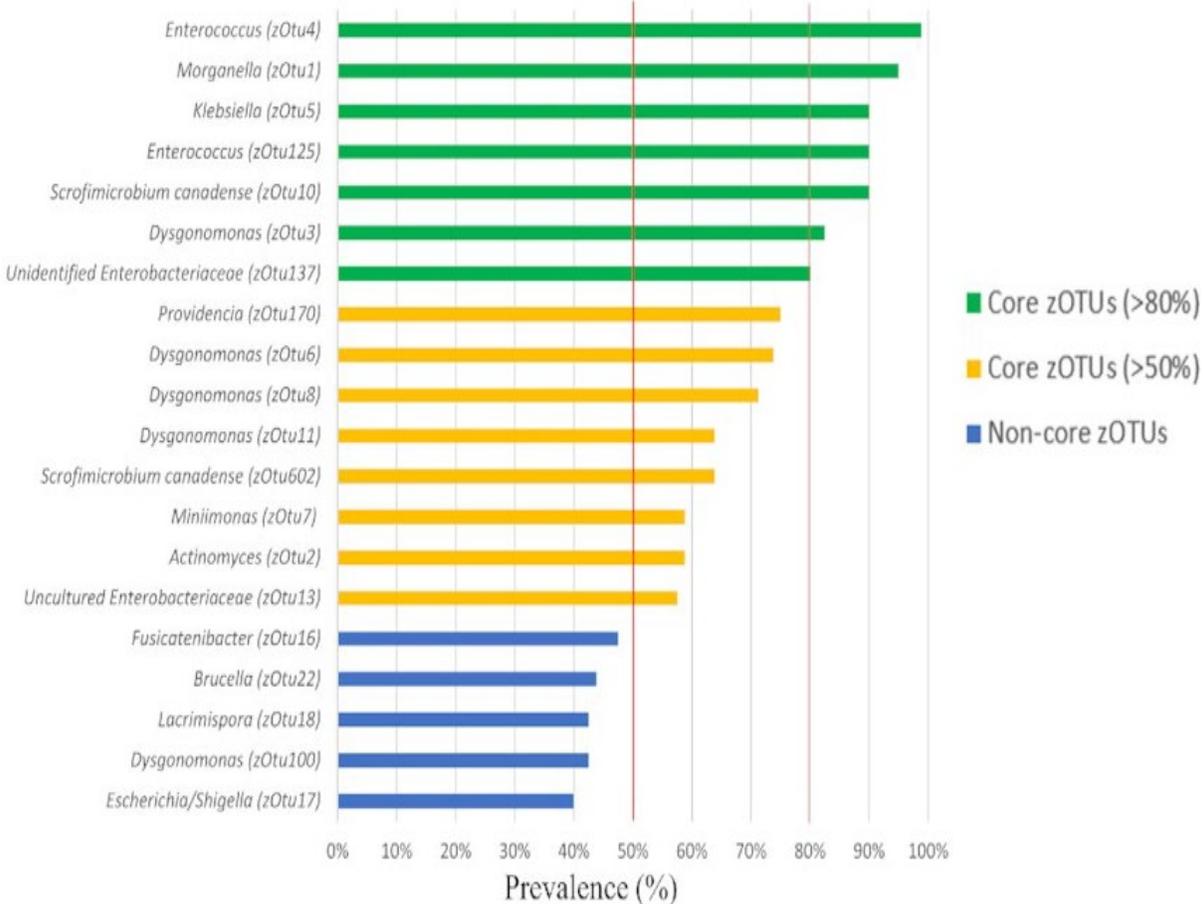




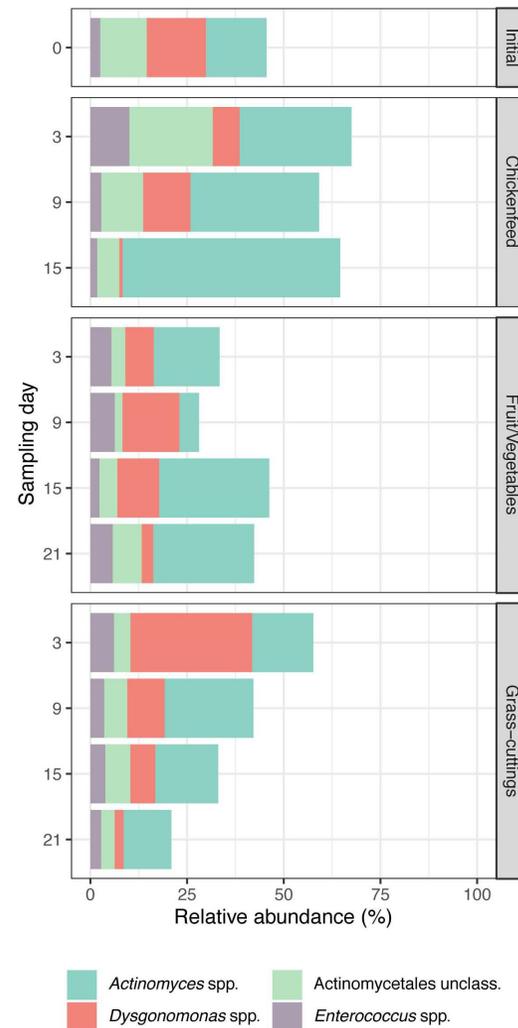
# Black Soldier Fly Larval Microbiome



(Bonelli et al., 2019)



(Ijdema et al., 2022)



(Klammsteiner et al., 2020)

- Re-occurring “core” taxa (e.g., *Enterococcus*, *Dysgonomonas*, *Scrofiimicrobium*; Ijdema et al., 2022)
- Diet influences microbiome, but taxa acquired in early larval stage may persist (Klammsteiner et al., 2020)
- Role of microbiome in digestion: improvement of BSFL growth, bioconversion
- Potential for microbiome in contaminant removal (e.g., see Bohm et al. 2024)



# Experimental Setup

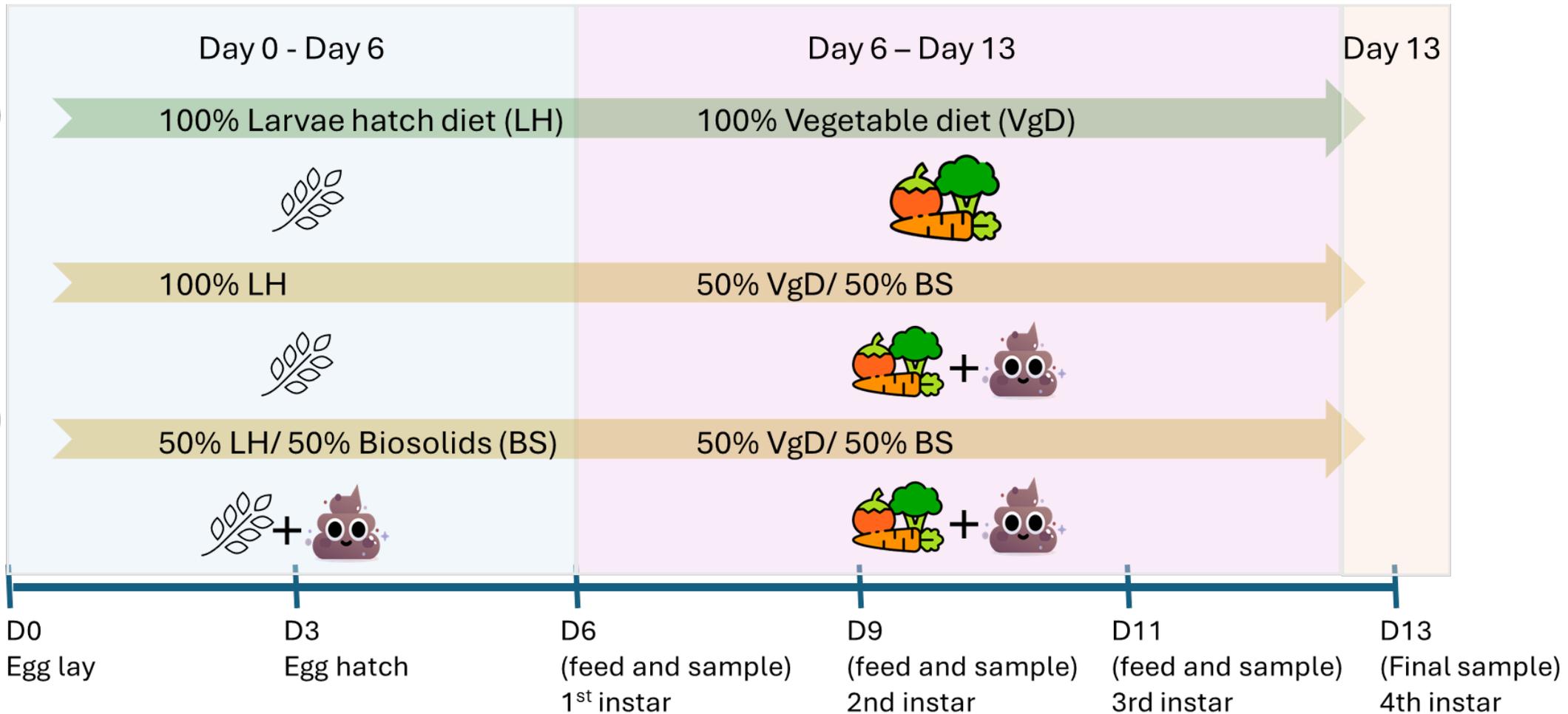
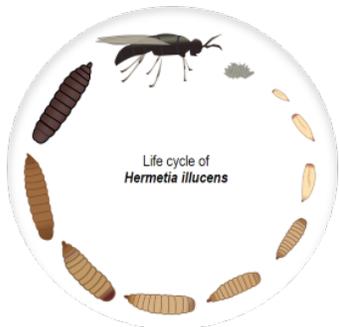


- How well do BSF larvae develop on 50% biosolids diet?
- Do larval microbiomes shift after transfer from a larval hatch diet to a biosolids diet?

Control

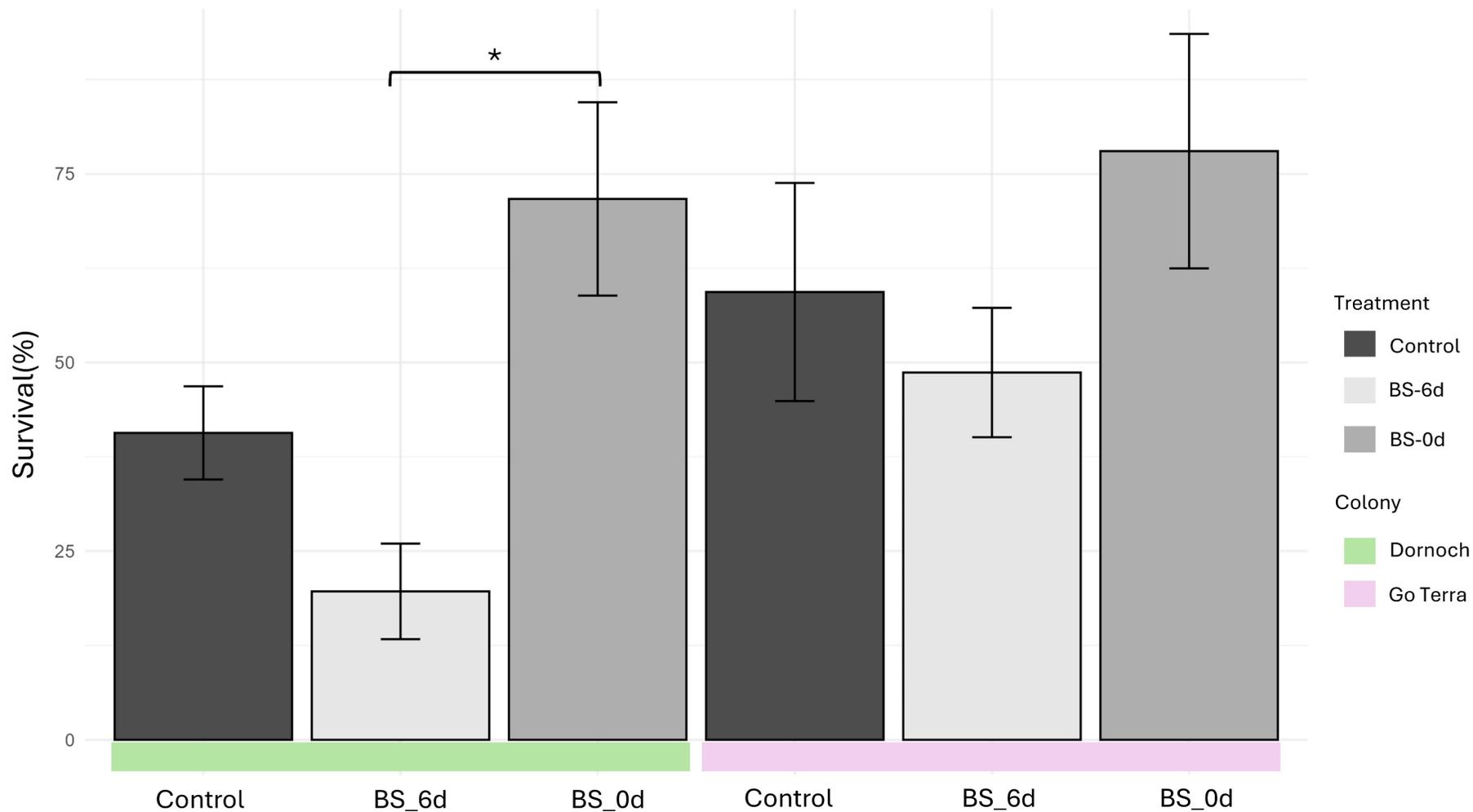
BS-6d

BS-0d





# Larval survival



- Reduced survival of one BSF line when switched to biosolid diet at day six
- Higher survival if fed biosolids from day 0

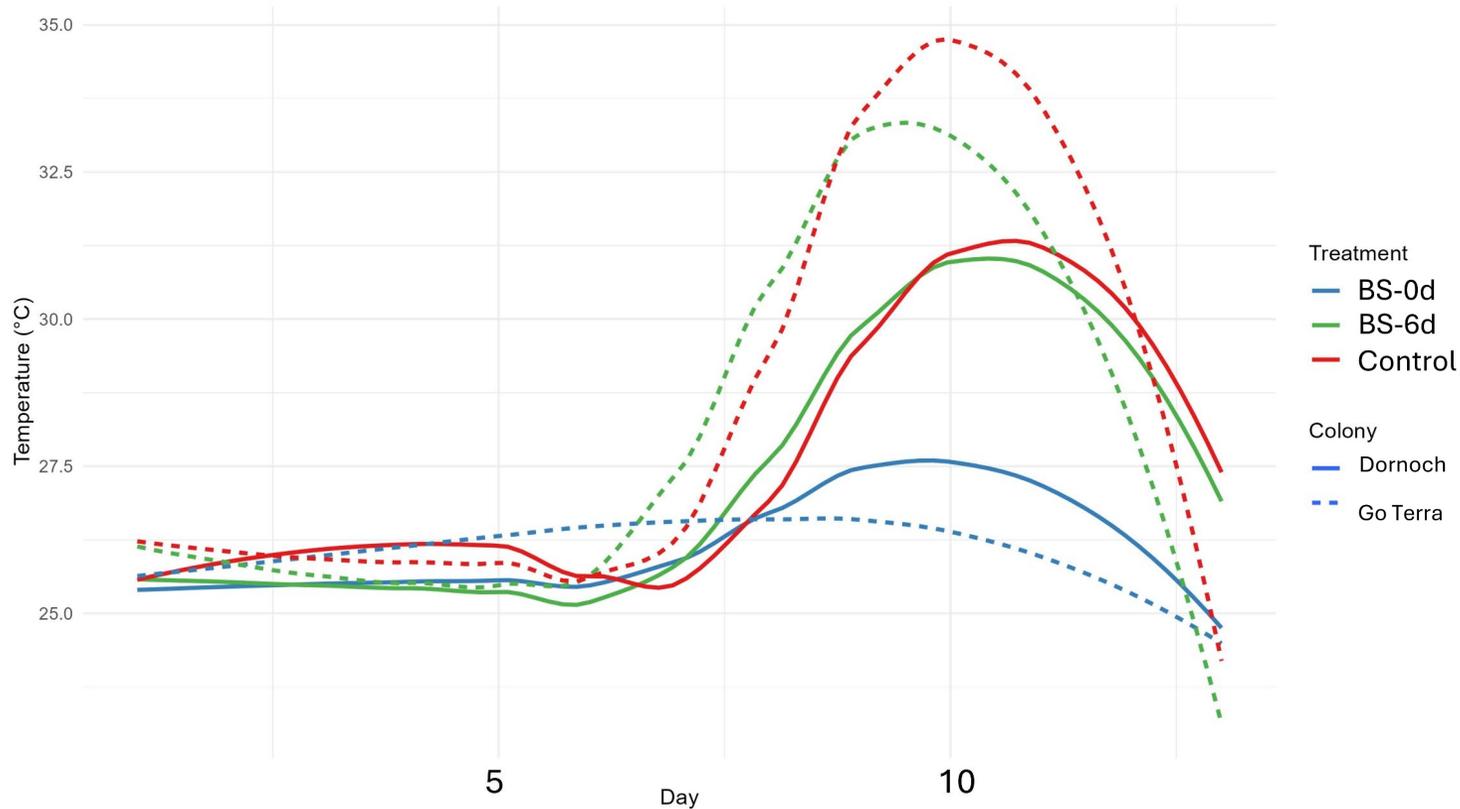
Control - Residue



BS- 0d - Residue



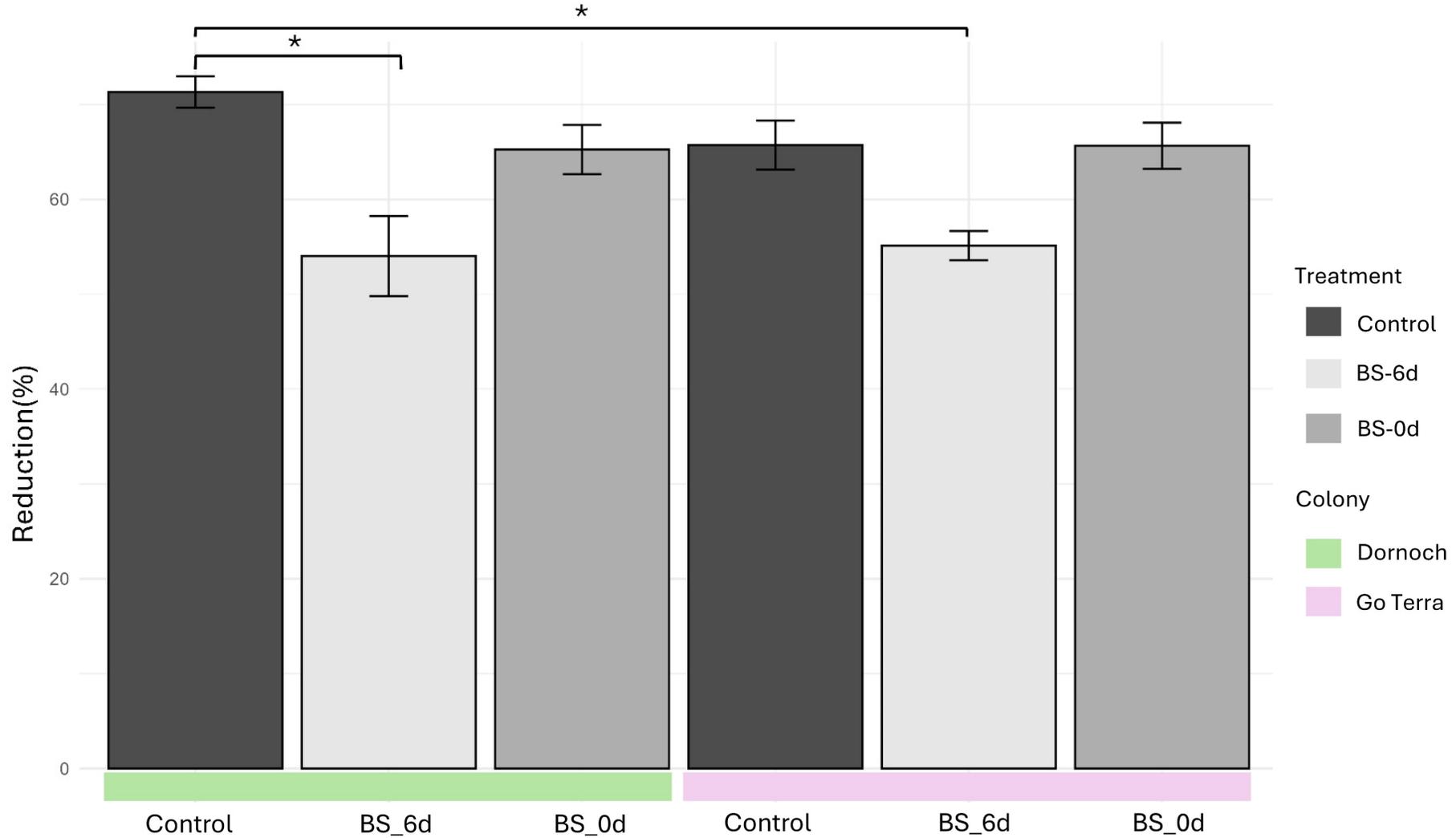
## Temperature – Lab vs Industrial colony



- Industrial line showed higher metabolic activity
- Lowest metabolic activity for larvae fed on biosolids from day 0

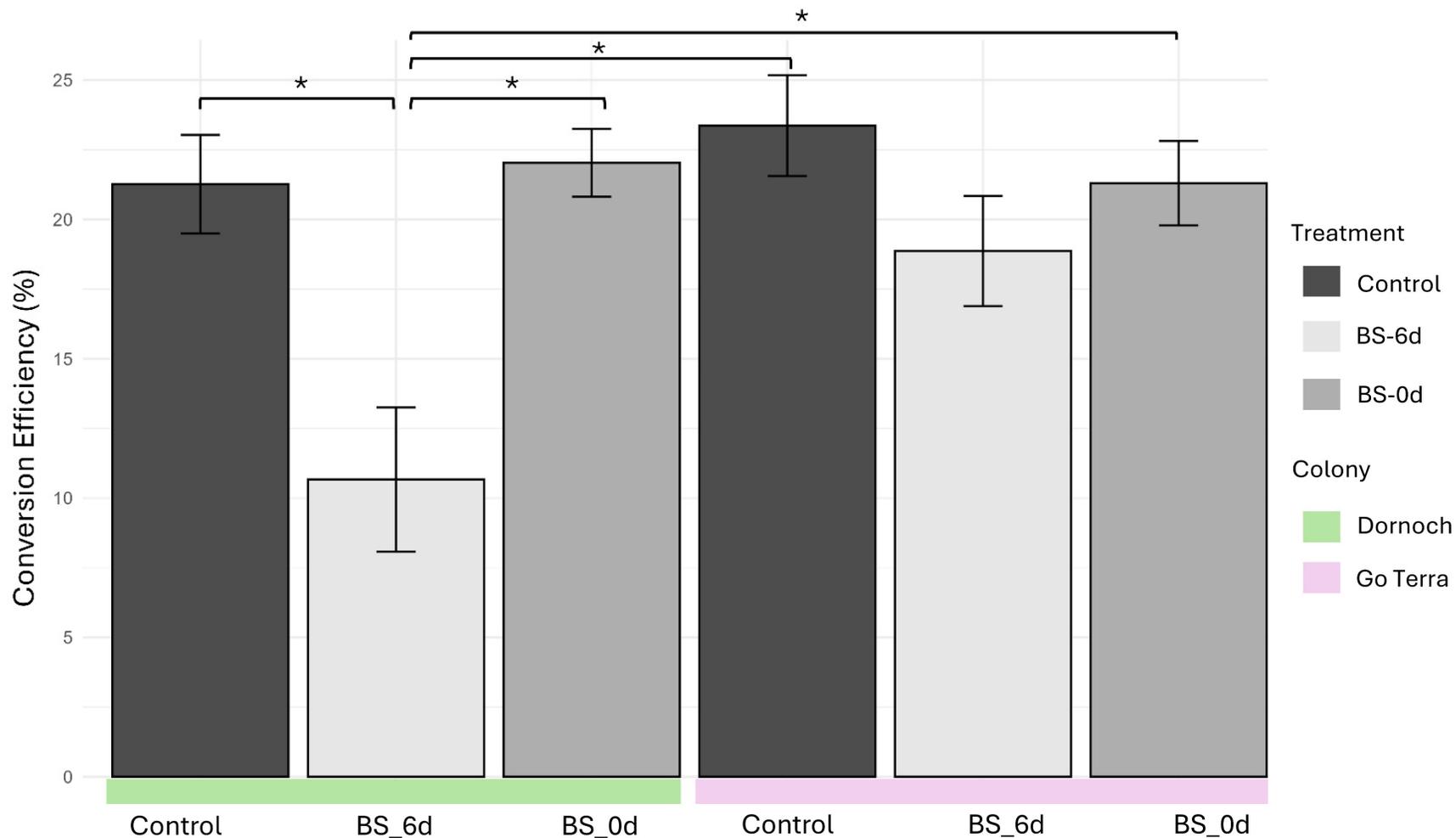


# Substrate reduction





# Conversion efficiency

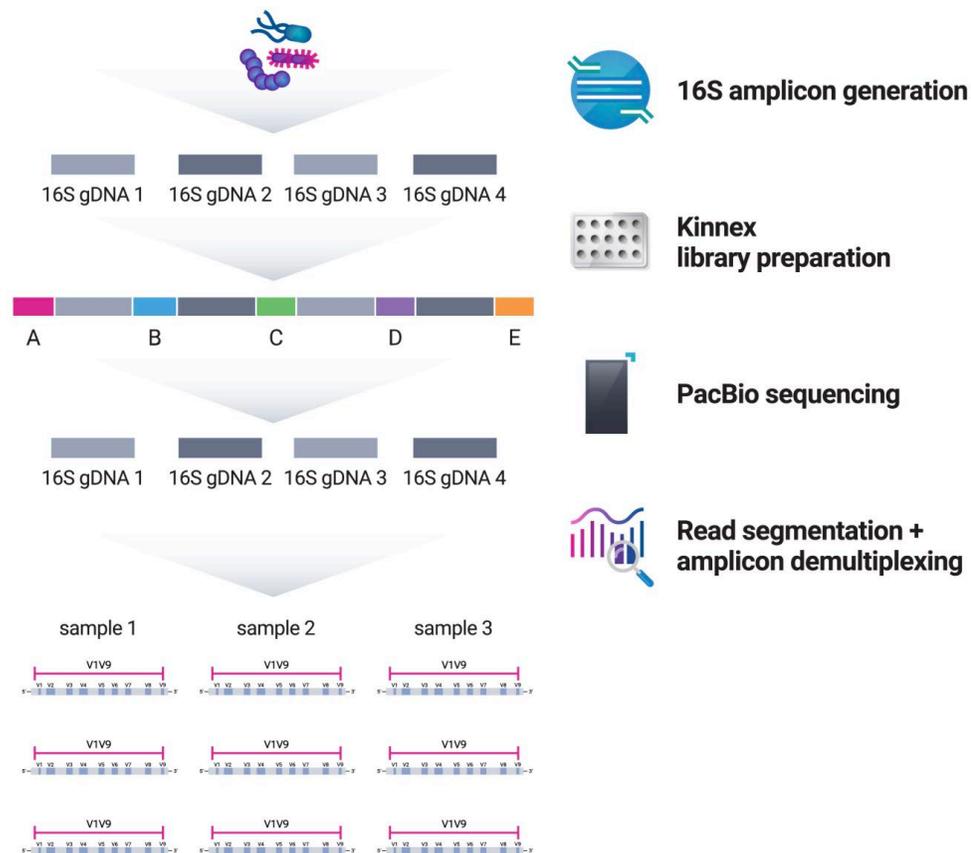


- Lower conversion efficiency for laboratory line switched to biosolids at day 6



# BSFL gut microbiome day 6

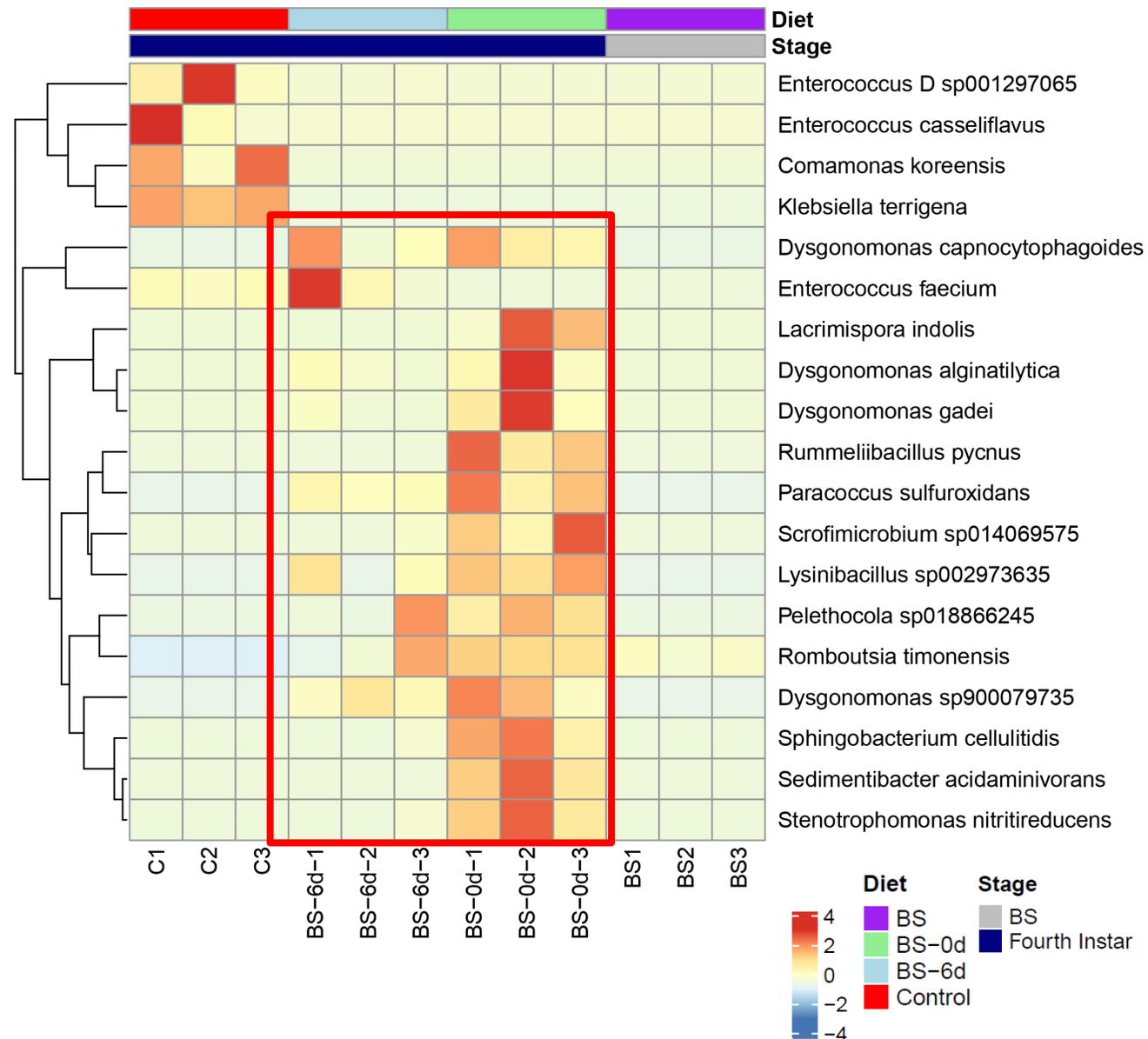
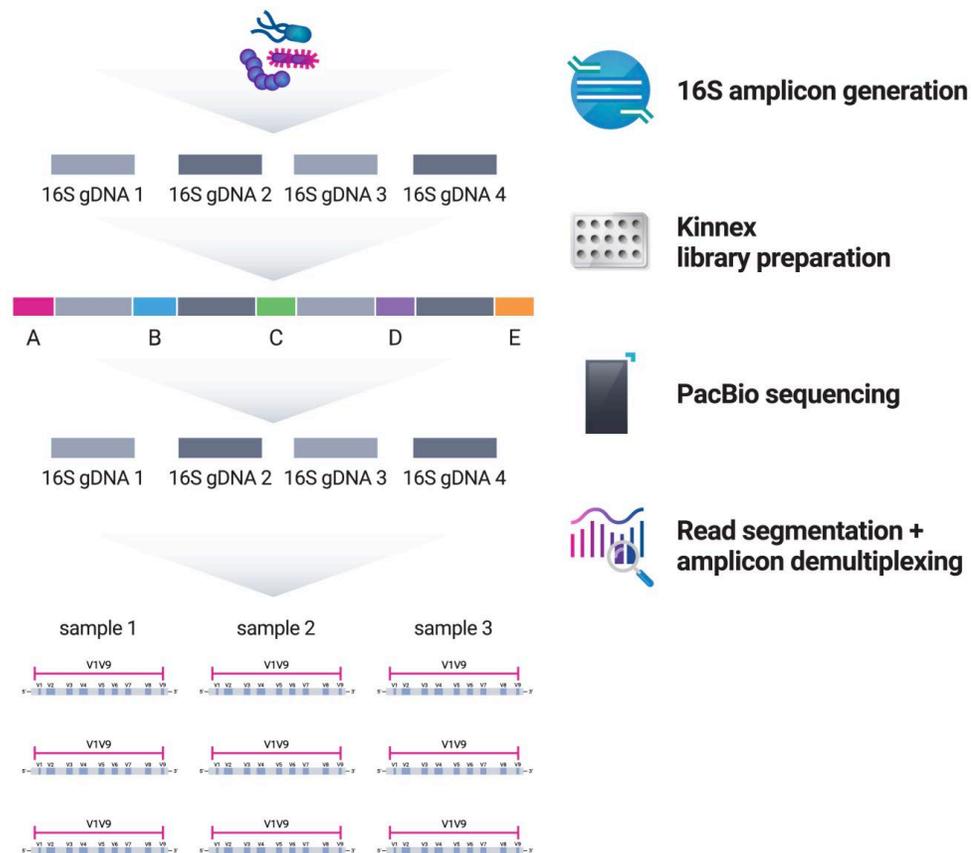
## PacBio HiFi full length 16S rRNA gene sequencing





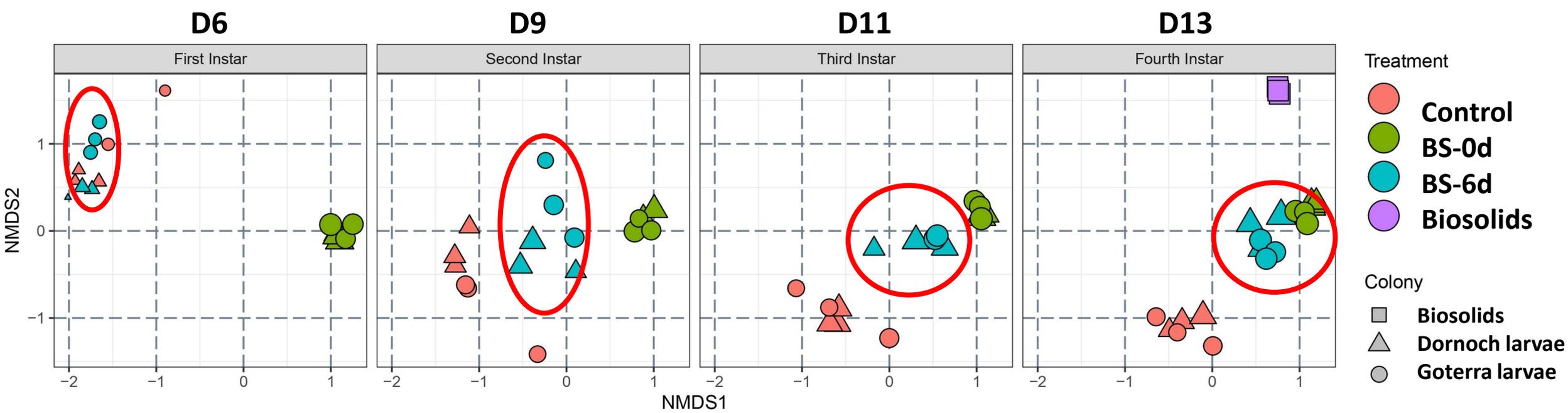
# BSFL gut microbiome day 13

## PacBio HiFi full length 16S rRNA gene sequencing





# BSFL Microbiome can shift after switch onto biosolids diet on day 6





# Conclusions

- BSFL can develop well on 50% biosolids diet, with substrate reduction >60% and conversion efficiency ~20%
- Differential survival between BSF lines implies complex interactions between host genetics and environment (diet); scope for improved lines for biosolids processing
- The BSFL microbiome is flexible and can be influenced by diet and life stage
- Distinct BSFL microbiome compared to diet, some major taxa similar to those found on other continents (e.g., *Dysgonomonas*, *Enterococcus*, *Scrofimicrobium*)
- BSFL microbiome can change after diet switching from larval rearing diet to biosolids



# Acknowledgements



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CSIRO | Brisbane

