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Effects of feeding substrate on greenhouse gas emissions during BSF larval development

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Context: Background and aims

Black soldier fly (BSF, *Hermetia illucens*) larvae provide:

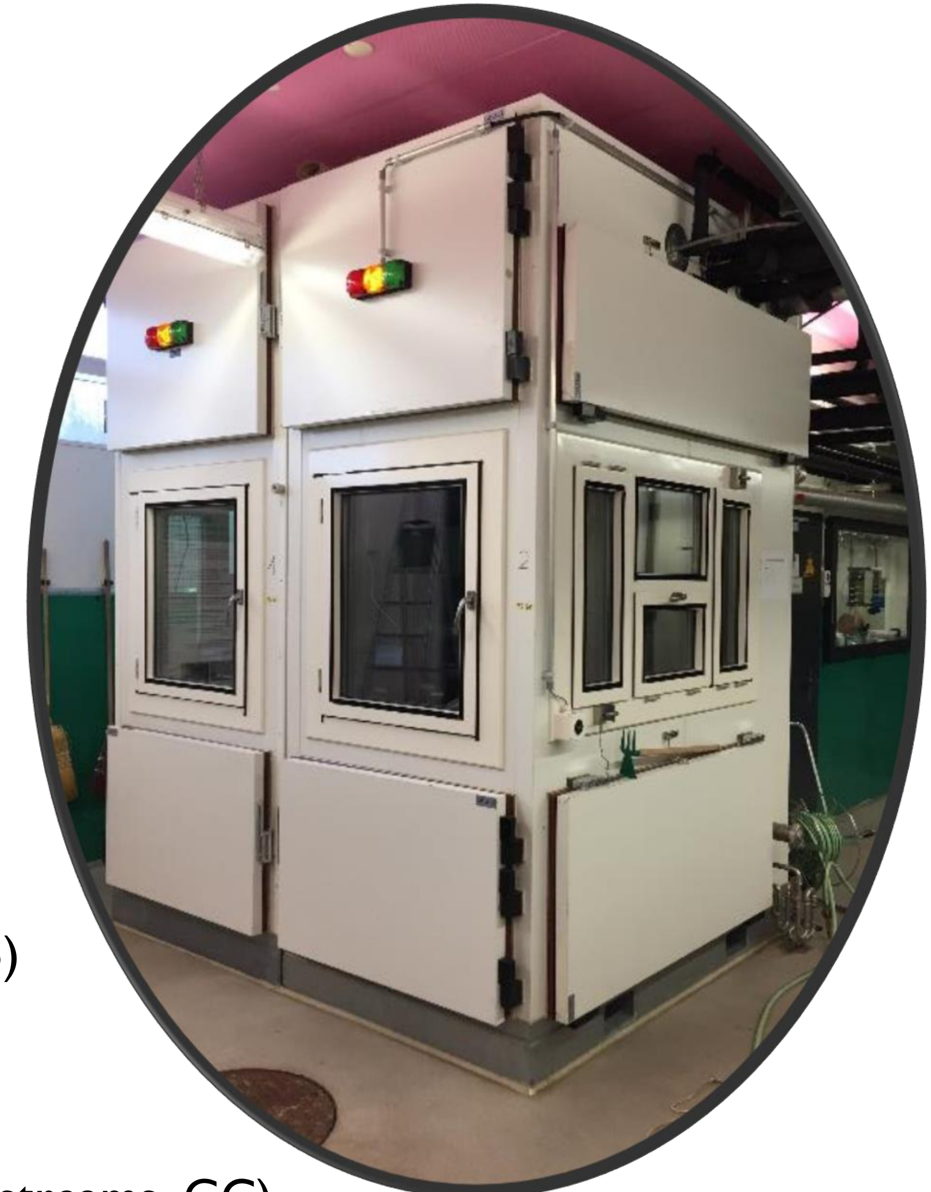
- conversion of various organic (waste) materials
- a novel protein source for fish and monogastrics feeding

Key for comparative sustainability assessments:
ecological footprints of BSF nutrient-cycling from by-products?

Scarce data on insect greenhouse gas (GHG) emissions:

- few species investigated - no BSF so far
- feed substrate variation not yet targeted
- just snapshots within developmental cycles assessed

Experimental setup



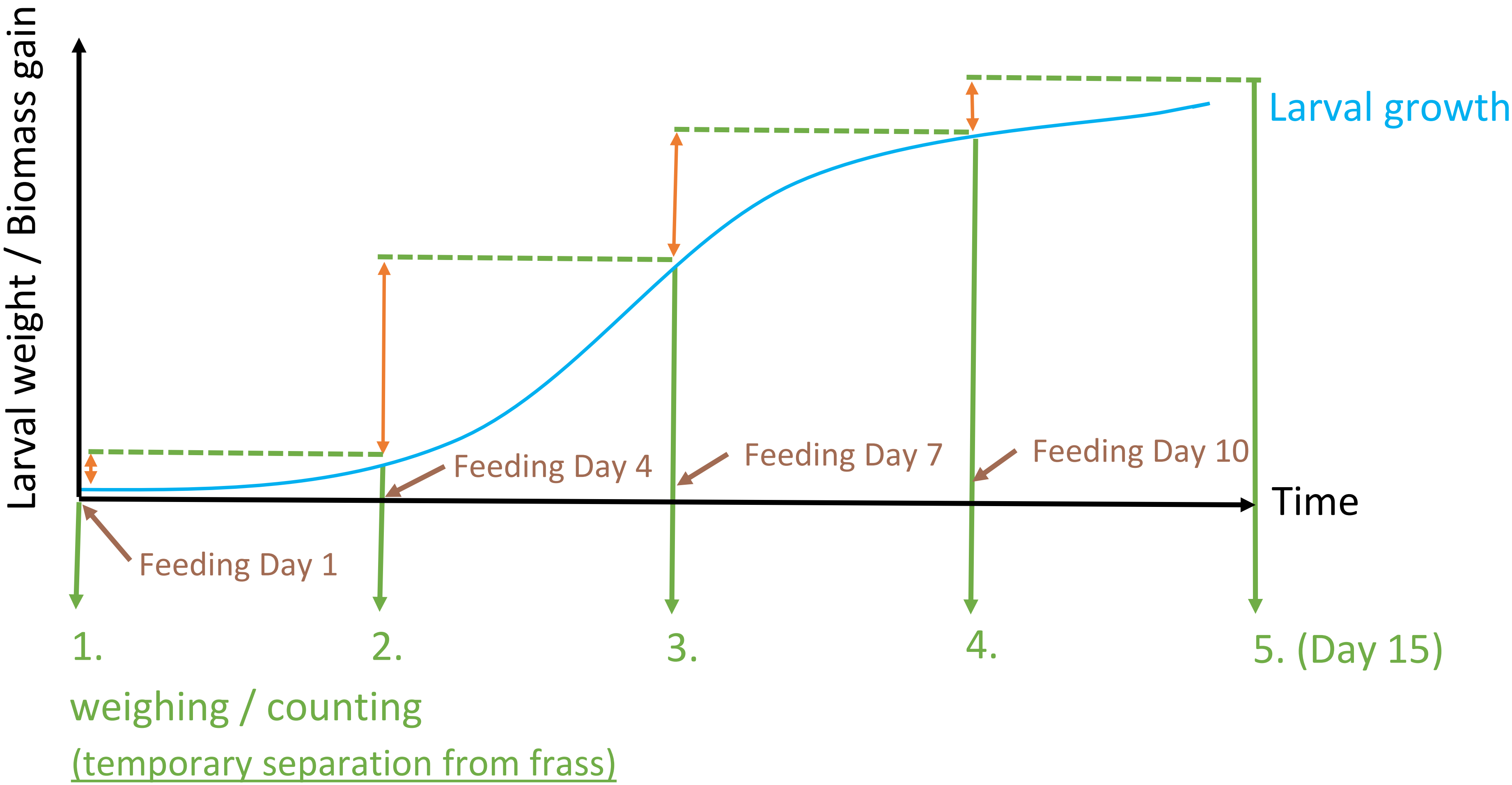
<u>Respiration chamber settings:</u>
- 27.5°C, 50% rel. humidity
- flow rate 0.1m^3/min

<u>Design:</u>
- 2 different mixed feed substrates
- 3 replicates à 3 x 10’000 larvae each
- 14 days period - covering ~4 larval instars (6 days old to >70% prepupae)

<u>Evaluations:</u>
- Larval biomass, counting & mean weights (5 occasions)
- Survival rate (end of experiment on day 15)

- CO_2 (every minute in chamber)
- CH_4 (every minute in chamber)
- N_2O (4-8 samples/day of inlet & outlet air streams, GC)

Experimental setup



Experimental setup

Basic composition of experimental feed substrates A and B

Ingredient	Feed A	Feed B
Banana discard	30%	10%
Apple pomace	15%	5%
Carrot pomace	15%	5%
Beet pulp	15%	5%
Spent grains (draff)	15%	45%
Pasta discard	10%	30%

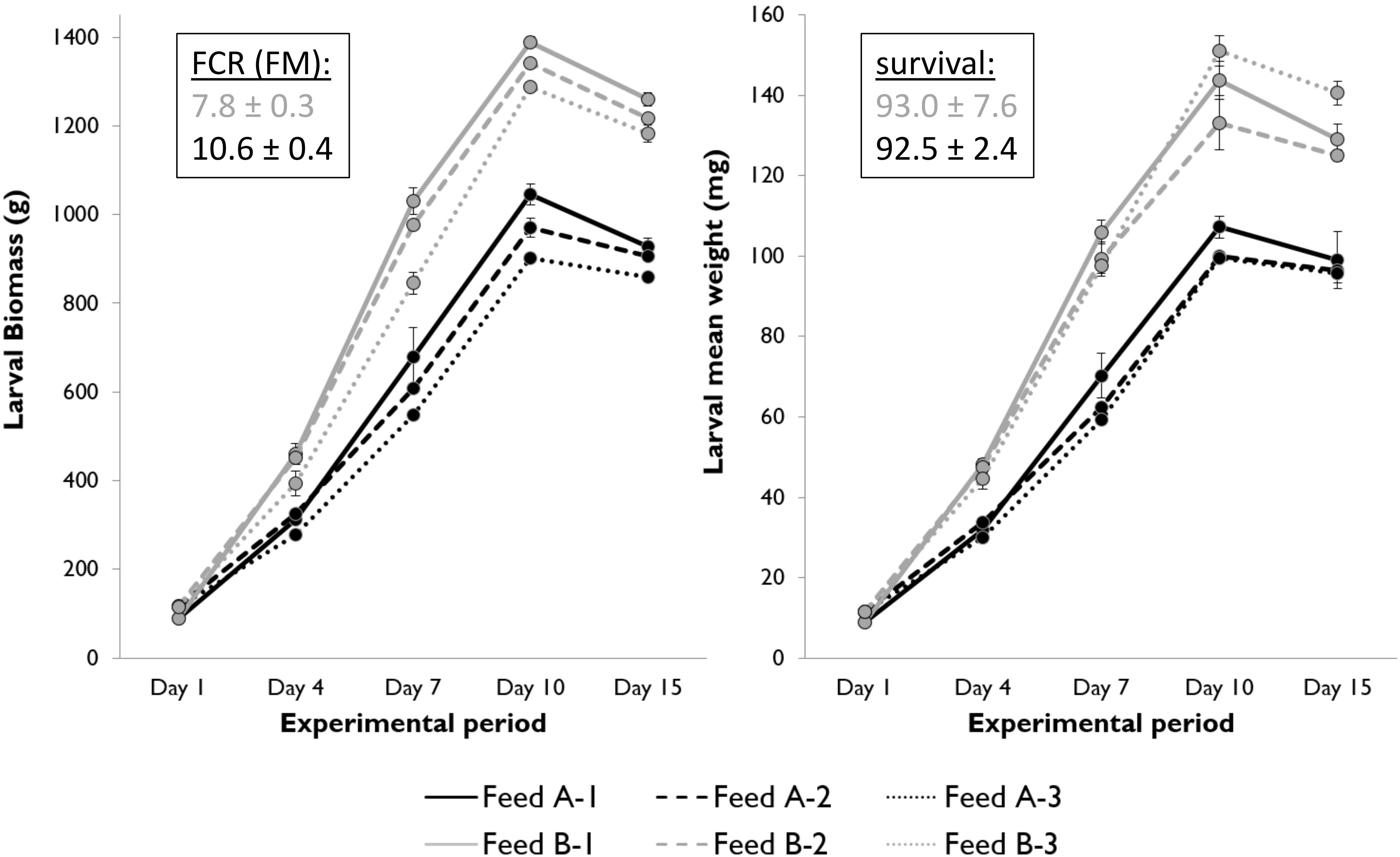
Single batches for each feed, adjusted to 23.7% dry matter

Applied feeding regime

Day	Portion (FM)
1	1800g
2	-
3	-
4	2500 g
5	-
6	-
7	3000 g
8	-
9	-
10	2200 g

~16 mg DM/larvae/day overall

Results: Larval performance



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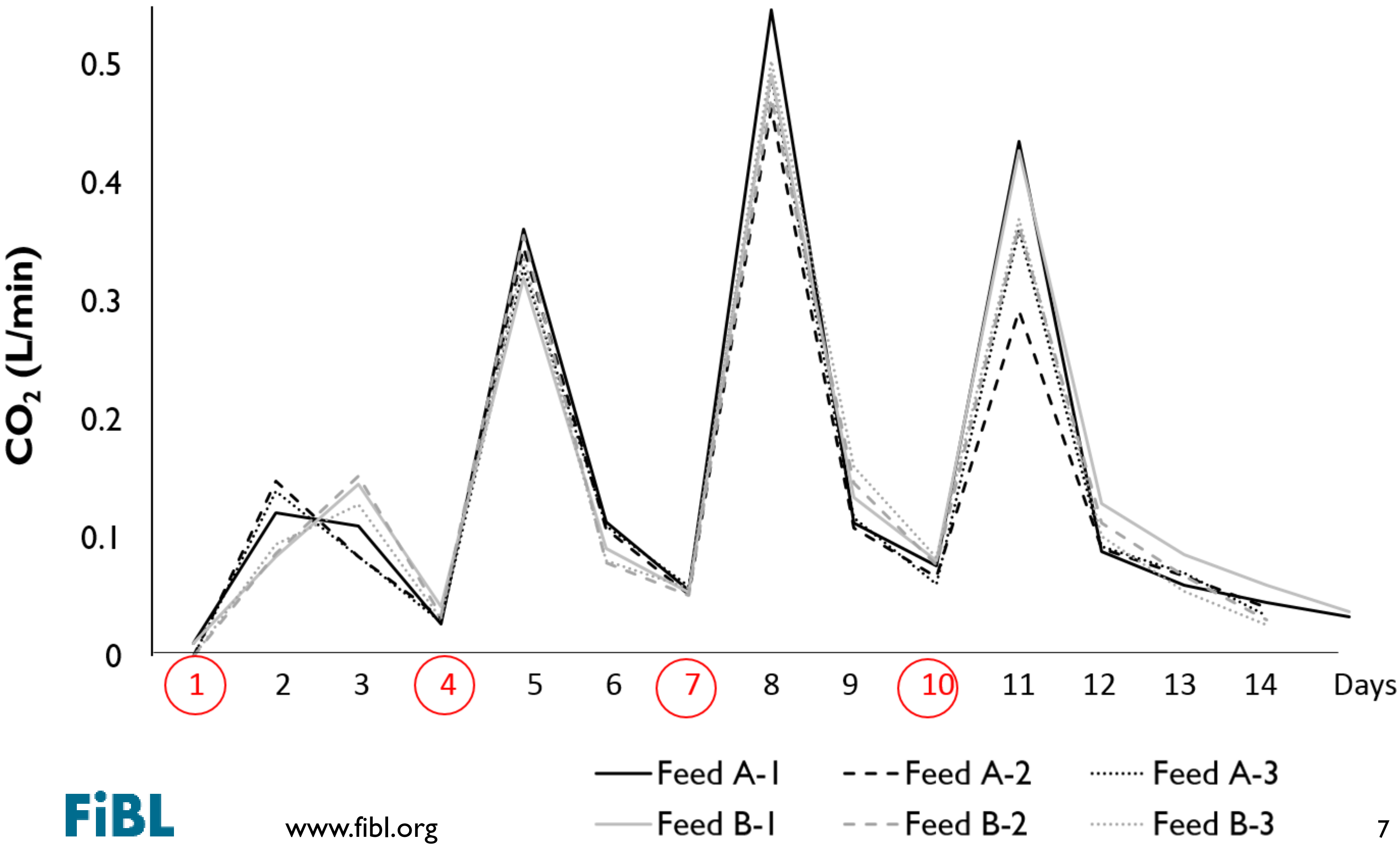
Results : CO_2 - emissions

Patterns (quantities & dynamics) similar for both feeds,
sharp peaks (24-48h post-feeding) roughly proportional to provided portions.
Unequal balances: higher biomass production for feed B.



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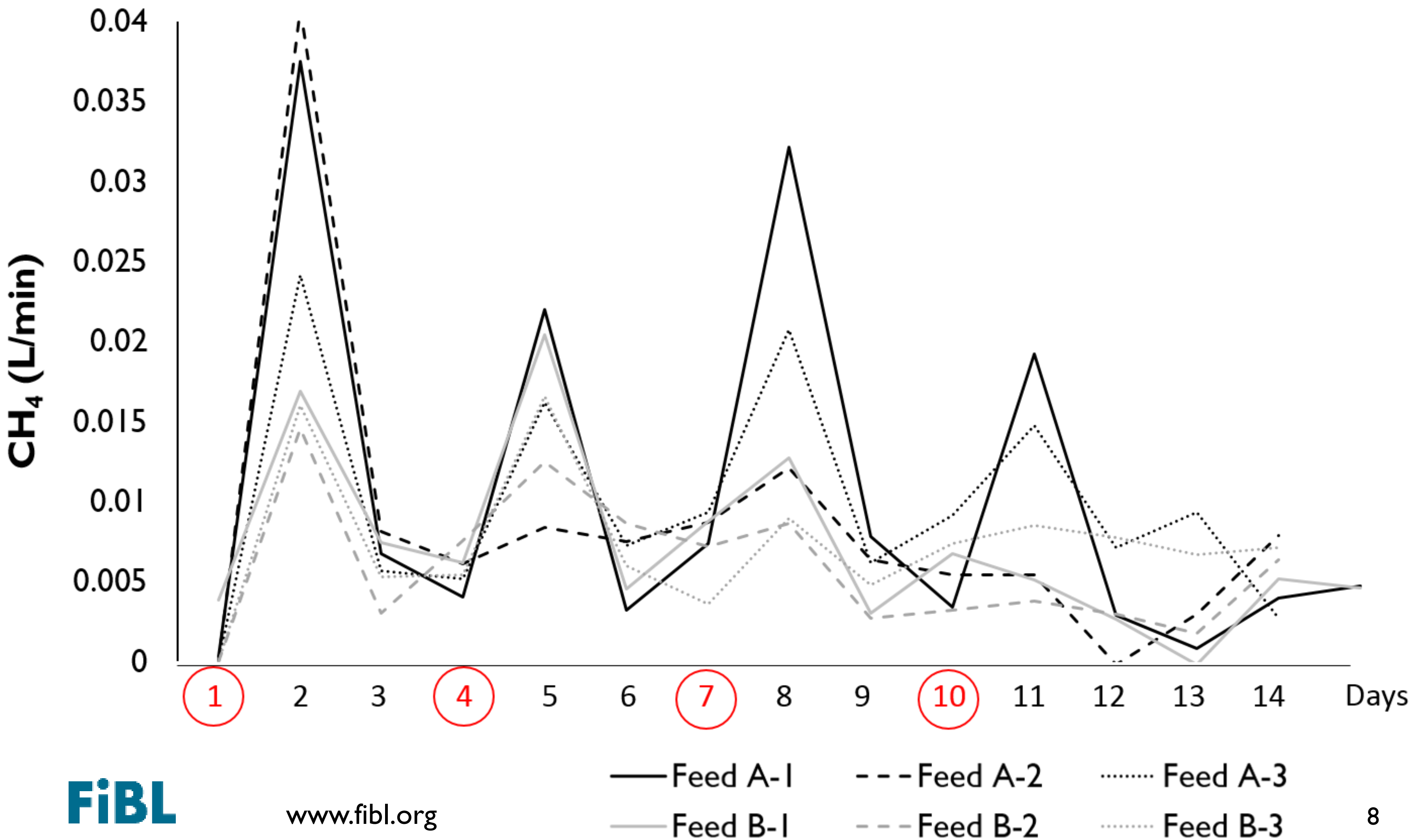
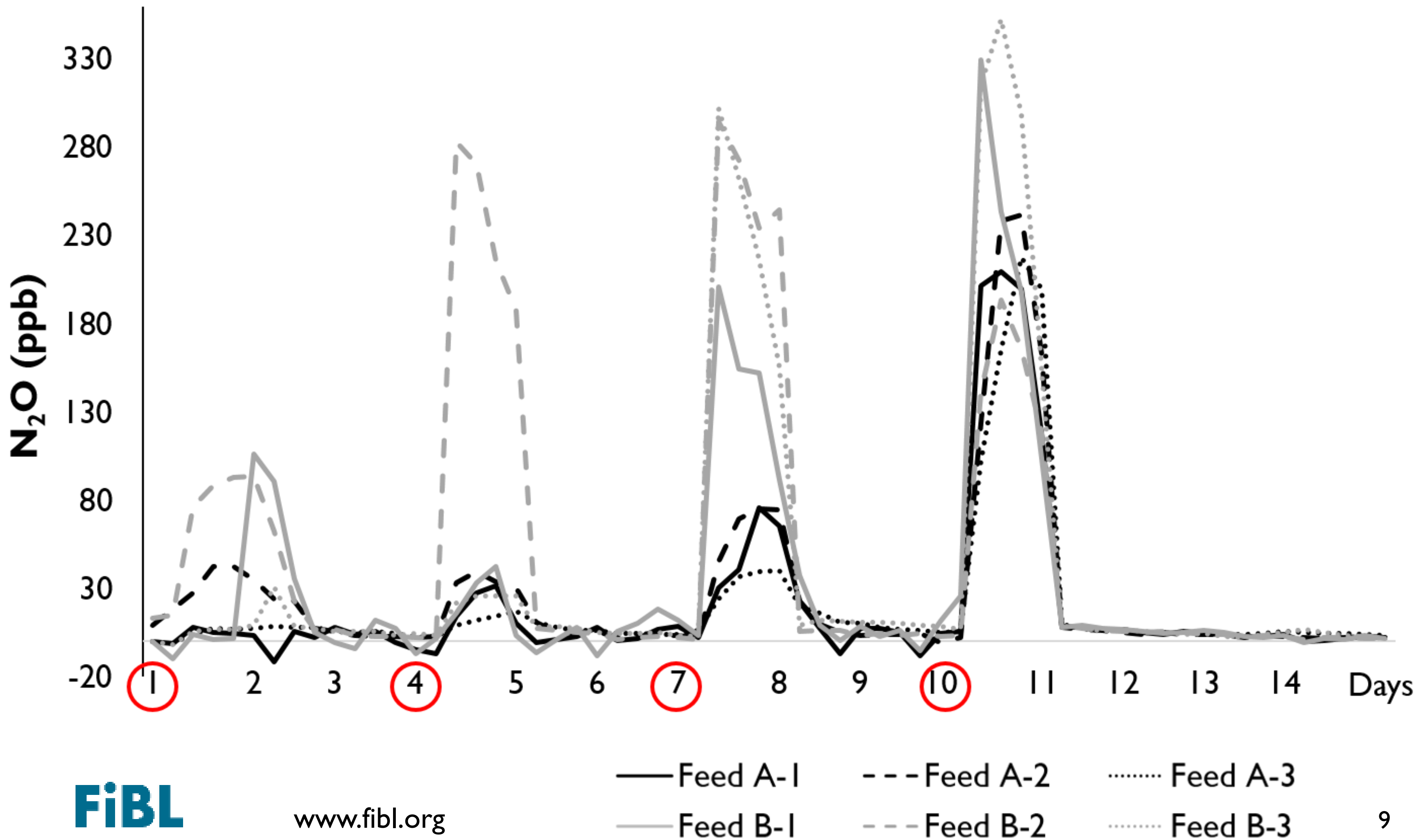
Results: CH_4 – emissions (25 CO_2 GWP-equivalents)

Different patterns for both feeds, but not all larval stages,
stronger dynamics over time & variation across replicates (not directly linked to portions).
Feed A: higher emissions coupled with lower larval biomass production.



Results: N_2O – emissions (298 CO_2 GWP-equivalents)

Different patterns for both feed substrates during most larval stages,
high variation across replicates for early phases.
Feed B: higher larval biomass productivity coupled with higher emissions.



Results: GHG emissions related to BSF larval biomass (gain)

	per kg larvae & day (mean)		per kg biomass gain (mean)	
	Feed A	Feed B	Feed A	Feed B
CO_2 (g)	205	161	2144	1646
CH_4 (g)	5	3	49	26
N_2O (mg)	3	4	33	45
tot. g CO_2 eq.	331	237	3379	2309

Conclusions & implications

Feed substrate, feeding events themselves & BSF larval developmental stage strongly impact on specific & overall GHG emissions

CH_4 & N_2O emissions likely related to microbes & type of feed, e.g. fiber-rich, excess nutrients

Neither feed nor frass, but their combination without larvae suggest substantial microbe-borne CO_2 emissions (not shown), which are yet systemically linked to BSF rearing

Considerable overall emissions of CO_2 equivalents during BSF fattening - not lower than in conventional monogastric livestock

Harvest prior to 6^{th} larval instar may improve GHG balances - pronounced (lipid?) metabolism in prepupae despite decreasing larval mean weights

Factors such as moisture & substrate depth, altered feeding regimes (timing, portions) or potentially beneficial microbes deserve further exploration

BSFL nutrient-cycling & protein production is not for free! Case-specific views indicated:

Poor feeds may come at high GHG costs despite low productivity, but avoiding surplus trophic levels for high quality feeds may generally be more sustainable

Thank you for your attention! – Questions?

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