Greenhouse gas emissions from soil-dwelling Scarabaeidae larvae (*Melolontha* spp.)

Carolyn-Monika Görres and
Claudia Kammann

Hochschule Geisenheim University

www.hs-geisenheim.de

Background

- Overall effect of soil-inhabiting arthropods on soil greenhouse gas fluxes still remains poorly quantified.
- Over 20,000 species of scarab beetles (Scarabaeidae) worldwide.
- Scarab beetle larvae harbour methane-producing microorganisms in their gut system, but how much do they actually produce?
- No field studies on direct greenhouse gas emissions from soil-inhabiting Scarabaeidae larvae available…until now:

Aim of this study:

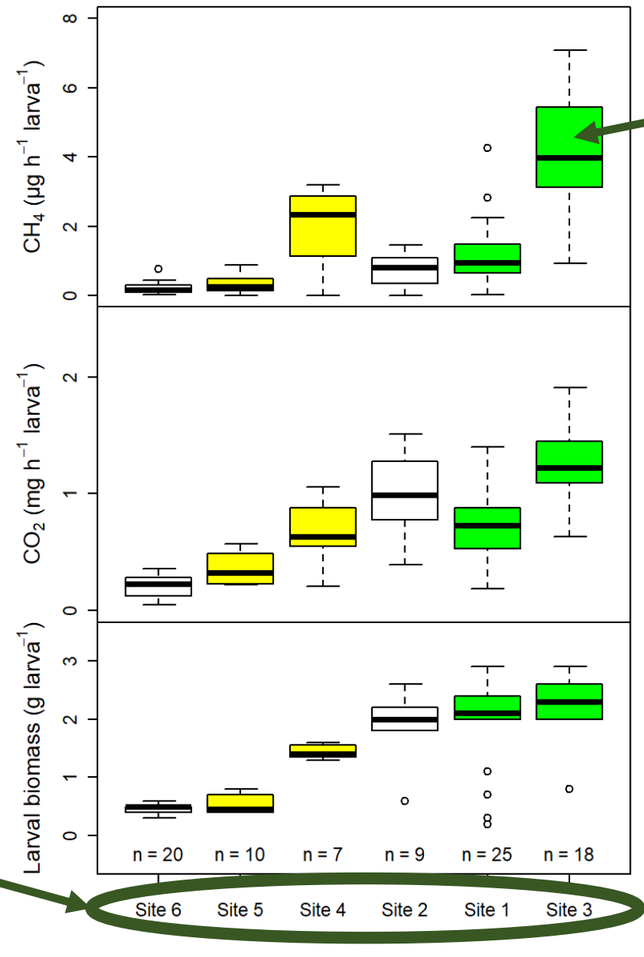
Provide first insights into field CO_2, CH_4 and N_2O emissions of scarab beetle larvae

Target species: cockchafers (*Melolontha* spp.)

- Life cycle of three to four years, majority of their lifetime belowground.
- Common Cockchafer (*Melolontha melolontha*): open landscapes (grasslands, orchards, vineyards, etc.)
- Forest Cockchafer (*Melolontha hippocastani*): as the name implies…forests
- Important pest insects. Larvae feed on roots, densities of >100 larvae m^2 have been recorded at highly infested sites.

Field incubations of freshly excavated larvae in Germany

Direct emissions of individual larvae

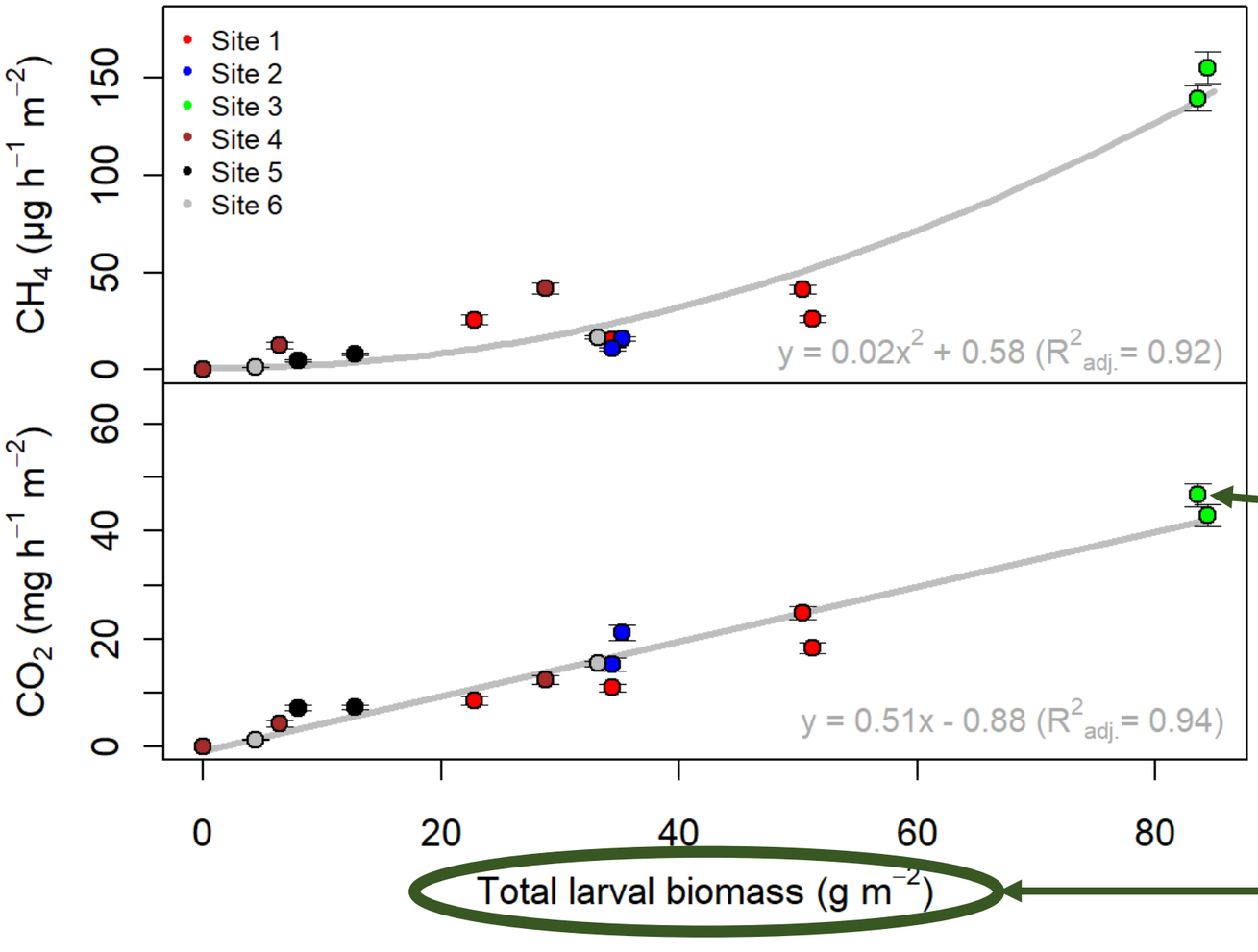


Colour coding of species:
Green = *Melolontha melolontha*
Yellow = *M. hippocastani*
White = *Melolontha* spp.

Field sites sorted by larval biomass

Large variability within and between sites

Cumulated larval emissions per excavated plot



Potential for using larval biomass for emission upscaling

dot = sample plot

Cumulated plot biomass

Simple emission upscaling exercise

- Cumulated larval plot emissions upscaled to 6 months (excluding larval winter rest).
- Upscaled values multiplied with 200,000 (= estimated ha colonized by *Melolontha* spp. in Europe).

10.42 to 409.53 kt CO_2 yr^{-1}

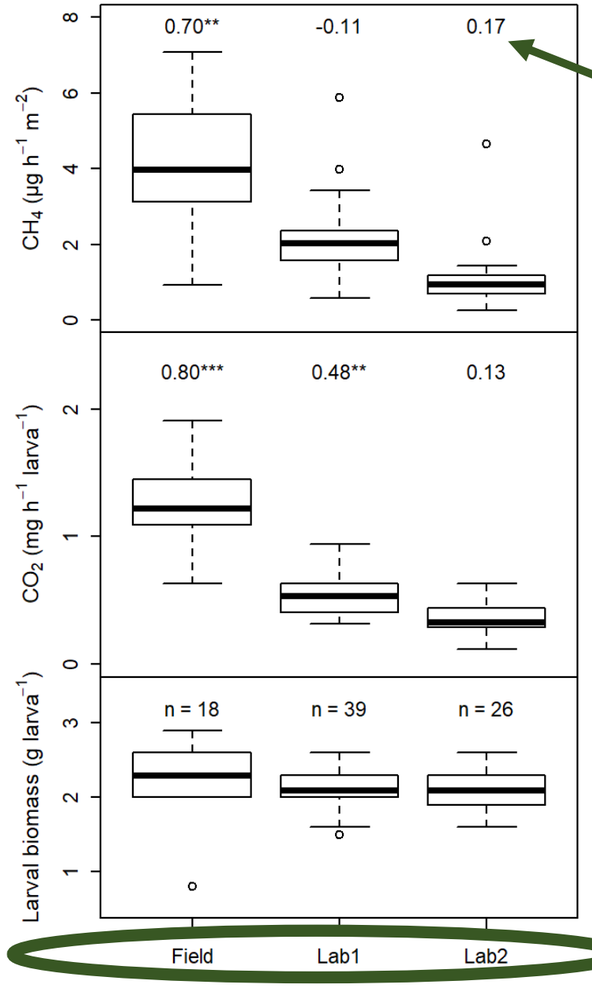
0.01 to 1.36 kt CH_4 yr^{-1}

- IMPORTANT: Larval emission estimates represent gross soil CH_4 production for these species only. No general estimate of scarab beetle larval biomass or colonized area available for Europe.
- How do scarab beetle larvae affect net soil CH_4 fluxes? Creation of temporary net CH_4 sources? Long term increase of soil CH_4 sink capacity?

Comparing field and laboratory incubations (Site 3)

Correlation between emissions and biomass disappeared in captivity

Reduced emission variability in captivity



Correlation between respective gas emission and larval biomass

Field = incubated directly after excavation
Lab1 = kept 7 days in the laboratory before incubation
Lab2 = kept 18 days in the laboratory before incubation

What about N_2O emissions?

- 13 of 64 larvae incubated in the field emitted N_2O (range between 1.3 and 90.4 ng N_2O h^{-1} $larva^{-1}$)
- 13 of 65 larvae incubated in the laboratory emitted N_2O (range between 1.8 and 43.7 ng N_2O h^{-1} $larva^{-1}$)

Emissions to sporadic for upscaling.

First N_2O emission measurements for scarab beetle larvae?

Concluding remarks

- Scarabaeidae larvae should not be neglected as sources of CO_2, CH_4, and N_2O in soil greenhouse gas flux research.
- Overall importance for soil net greenhouse gas fluxes remains to be quantified.
- Need for biodiversity monitoring of soil-dwelling scarab beetle larvae (biomass estimates and distributions, spatial and temporal activity patterns) in particular and soil fauna in general.
- Need for a non-invasive method to measure larval greenhouse gas emissions *in situ*. Bias in emission estimates due to current sampling method not known yet.
- We are working on solving these issues with **soil acoustics** and **stable carbon isotopes**.

Acknowledgements and further information

The presented study is available as preprint at bioRxiv:

**Görres, C.-M., Kammann, C. (2019): Scarabaeidae larvae are neglected greenhouse gas sources in soils.
doi: https://doi.org/10.1101/713784 (currently under revision for PLOS One)**

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For more information: @CarolynGorres (Twitter), carolyngoerres.wordpress.com