gerstle@uni-landau.de

Specific mosquito control agent? Reduction of non-target organisms Chironomidae and Odonata observed in semi-field mesocosms treated with *Bacillus thuringiensis* var. *israelensis*

Verena Gerstle[1], Maximilian Gerken[1,2], Alessandro Manfrin[1], Sara L. Kolbenschlag[1], Mirco Bundschuh[1], and Carsten A. Brühl[1]

[1] iES Landau, Institute for Environmental Sciences, University of Koblenz-Landau, Fortstraße 7, D-76829 Landau in der Pfalz, Germany
[2] Eusserthal Ecosystem Research Station, University of Koblenz-Landau, Birkenthalstraße 17, D-76857 Eusserthal, Germany

Introduction:

Bacillus thuringiensis var. *israelensis* (Bti) is widely used as a biocide to control biting mosquito populations in wetlands. Despite being considered to specifically act on larvae of target organisms, i.e. mosquitoes, Bti was shown to reduce the density of non-target Chironomidae in laboratory and field studies [1,2]. Since larvae of Chironomidae are a key food source in aquatic food webs [3], their reduction by Bti may cascade through the aquatic food web and alter the structure and composition of higher trophic levels in benthic communities.

Methods:

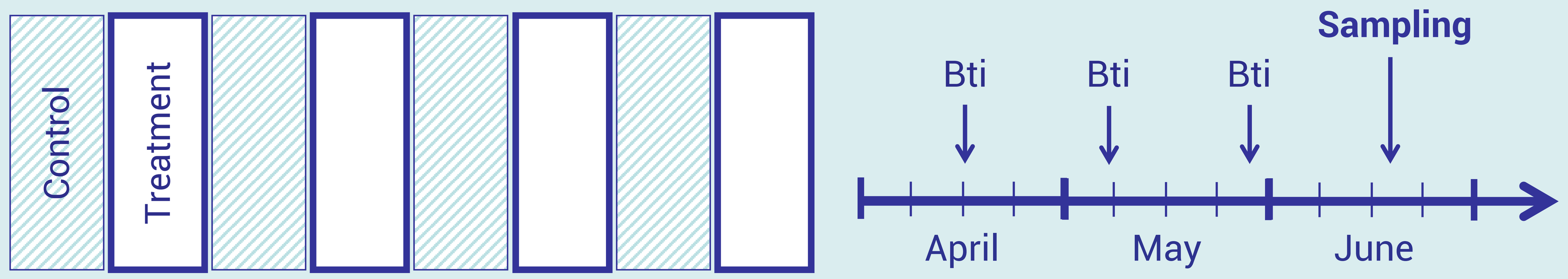

Figure 1: Depiction of stagnant freshwater semi-field mesocosms (left; A≈120 m²). Treatment mesocosms (n=4; white) were treated three times with double field rate of VectoBac WDG (2.88x10⁹ ITU/ha; as used in water bodies deeper than 20 cm) in a three-week time interval (right).

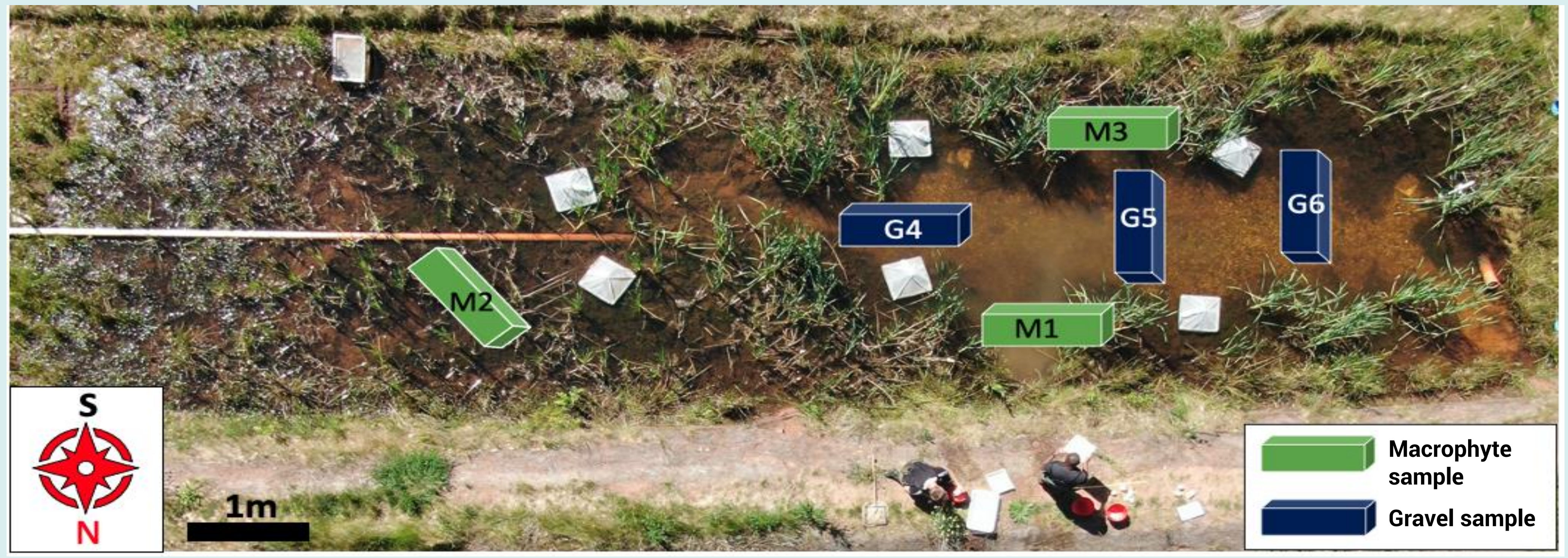

Figure 2: Top view of sampling points in habitat types 'macrophytes' (green) and 'gravel' (blue; microlithal = coarse gravel, grain size ~ 1-3 cm) in one mesocosm. At each sampling point (n=3 per habitat), sampling was conducted over one meter using a kicknet (500 µm).

In a nutshell:

- The use of the biocide Bti in wetlands affects aquatic Chironomidae larvae
- Results suggest cascading effect at higher trophic levels (i.e., Odonata)
- Such a scenario may be particularly true in small stagnant water bodies where many predators depend on Chironomidae larvae as a key food source

Results & Discussion:

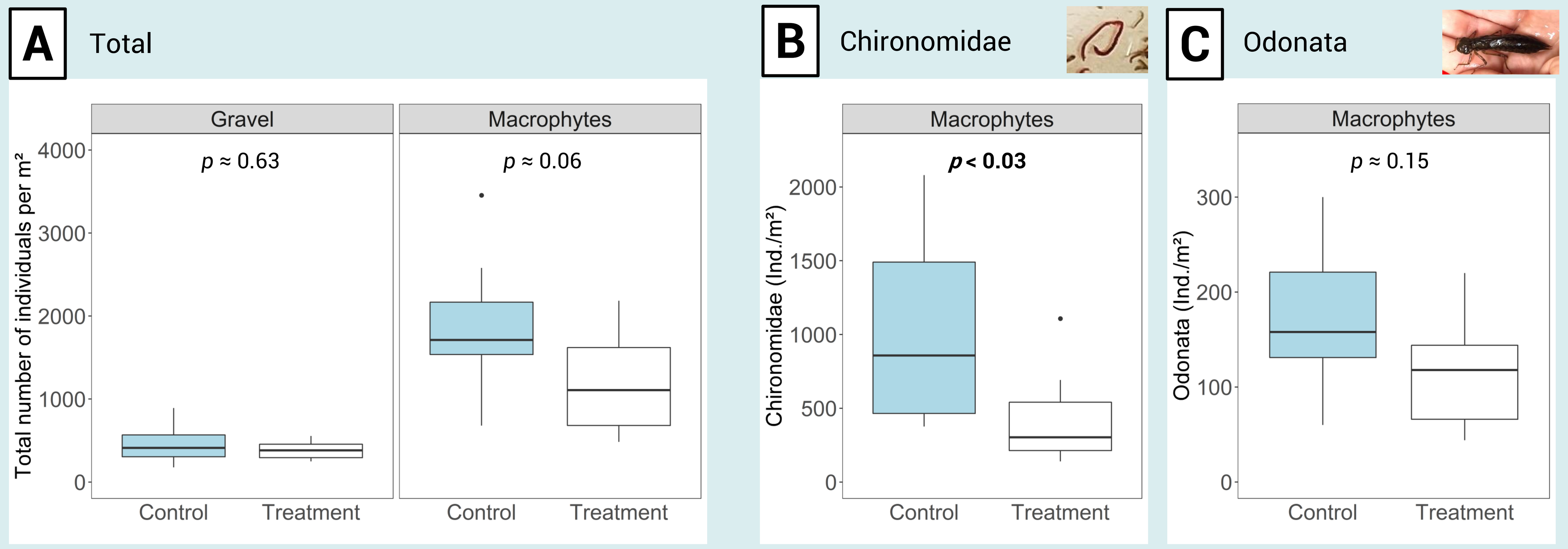

Figure 3: Boxplots showing **(A)** the total benthic abundance sampled per m² in habitat types 'gravel' and 'macrophytes', **(B)** the abundance of Chironomidae larvae per m² in macrophytes, and **(C)** the abundance of Odonata larvae per m² in macrophytes. Statistically significant differences are printed in **bold**; *p* values were obtained by linear mixed effects models using treatment/habitat as fixed and ponds as random effects.

Regardless of the treatment, the habitat type 'macrophytes' showed a higher species diversity (data not shown) as well as an up to four times higher total abundance compared to the habitat type 'gravel' ($p < 0.01$; Fig. 3a). In macrophytes, Chironomidae was the taxa most affected by Bti with a significant ($p < 0.03$) reduction in abundance of approximately 60%, 40%, and 80% for the subfamilies Chironominae, Tanypodinae and Orthocladinae, respectively (Fig. 3b; cf. [1]). Although not significant ($p \approx 0.15$), overall less number of Odonata larvae were found in the treatment compared to the control in the macrophyte habitat (~35%). Since Odonata are not directly susceptible to Bti [4], the trend in reduced Odonata larvae may be the consequence of an interrupted food web either due to the substantial reduction of Chironomidae abundance [5] and/or possible cannibalism occurring in older larval stages of Odonata, most likely depending on prey availability. We conclude that Bti reduces the number of Chironomidae larvae and the effects can cascade to other groups of the benthic community at higher trophic levels.

References: [1] Allgeier et al. (2019) *Ecotoxicology and Environmental Safety* 169; [2] Bordalo et al. (2021) *Environmental Pollution* 282; [3] Armitage (1995) *Springer Netherlands*; [4] Painter et al. (1996) *Environmental Entomology* 25; [5] Jakob & Poulin (2016) *Insect Conservation and Diversity* 9.

Acknowledgements: This study was funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Fundation) – 326210499/GRK2360. Furthermore, we thank Eric Bollinger, Tobias Graf, Clara Mendoza-Lera, Sina Riethmüller and Stephen Osakpolor for their help during sampling and analyses.