MODELLING TOXIC EFFECTS ON CHAOBORUS CRYSTALLINUS POPULATIONS UNDER FIELD CONDITIONS – AN INDIVIDUAL–BASED SIMULATION STUDY

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Introduction

- This study presents a modelling approach for the extrapolation of toxic effects from individuals in the laboratory to populations in the field.
- As a model organism for emerging insects, we used the multivoltine aquatic phantom midge Chaoborus crystallinus, which is a common pelagic invertebrate predator in ponds and is known as a frequently very sensitive organism to pesticide exposure.
- We used an individual–based population model for C. crystallinus, which was formerly validated with experimental data from aquatic outdoor mesocosms.
- The Chaoborus population model was coupled with the General Unified Threshold model for Survival (GUTS, Jager et al. 2011) explicitly simulating toxicokinetics and toxicodynamics.
- The advanced coupled model was validated using data from aquatic outdoor mesocosms treated with triphenylin (TPT).

Modeling approach

Population dynamic of Chaoborus crystallinus was simulated depending on larval starting densities, food conditions, water temperature and photoperiod. Whole populations of the ponds (volume: 4.9 m³) were modelled under outdoor weather conditions. In this model the individual chaoborids are explicitly modelled and population dynamics emerge directly from the interactions of the individuals simulated by their life-cycle.

The GUTS parameterisation was based on data derived from toxicokinetic and toxicological experiments with individual Chaoborus larvae exposed to radiolabelled triphenylin (TPT) in the laboratory. Here we selected the scaled damage as dose metric and the assumption of stochastic death.

Migration of the adults:
- 95% emigration rate of the adults
- no immigration from outside the mesocosm facility
- even distribution of the egg-laying midges over all uncovered mesocosms

Results

Experimental mesocosm setup:
- mesocosm experiment from 10 June (day – 14) to 02 September 2009 (day 70)
- One application of 30 µg TPT/L on day 0
- Open mesocosms (control ponds and TPT treated ponds) and closed TPT-treated ponds (covered by nets), 3 replicates each
- Water temperature: 20.6 ± 1.5 °C
- DO₂ (TPT): about 9 days
- LC₅₀ for all larval stages: 19 µg TPT/L
- In most of the mesocosms, macrophytes covered > 60 % of the water surface

Exposure in the mesocosms

Fig. 3: Concentration of triphenylin in the treated ponds.

Simulation of the control populations

Fig. 5: Measured and simulated larva abundance in the open control mesocosms without TPT.

Simulation of the TPT treatments

Fig. 7: Measured and simulated larva abundance in the closed treatments using an LC₅₀ approach (only acute toxicity was taken into account).

Simulation of recovery

Fig. 8: Measured and simulated larva abundance in the closed treatments using the GUTS approach.

Fig. 9: Measured and simulated larva abundance in the open treatments using the GUTS approach.

Conclusions

- The untreated control population could be reproduced using the Chaoborus model without further calibration. Only the specific migration rate of adult chaoborids has been adapted to the present study.
- Based on standard laboratory TKTD data, the dynamic of the triphenylin treated populations could be well predicted by the model using the GUTS approach. On the contrary, other more simple concepts such as the acute toxicity failed for triphenylin.
- Despite the fact, that only a slight recolonisation occurred in the open treatment ponds in this particular study, the model fits well with the observed (allochthonous) recovery process.


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