

How soil properties affect egg development and larval longevity of a grassland insect pest - an empirically based model

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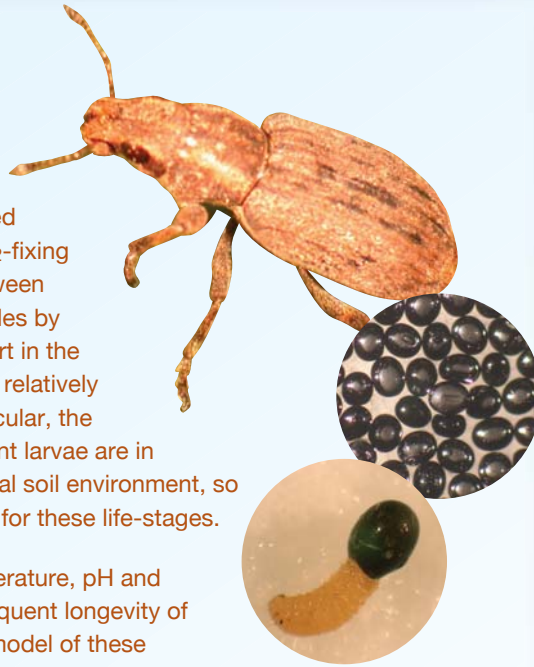
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The clover root weevil (*Sitona lepidus* L.) is a destructive pest of white clover in temperate grasslands.

Adults lay thousands of eggs that give rise to soil-dwelling larvae that initially feed on the root nodules housing symbiotic *N₂*-fixing *Rhizobium* spp. bacteria. The period between egg hatch and consumption of root nodules by larvae is probably the most vulnerable part in the lifecycle, and if larvae do not locate roots relatively quickly they will die of starvation. In particular, the shells of eggs and the cuticles of emergent larvae are in constant physical contact with the external soil environment, so the nature of the soil is potentially critical for these life-stages.

This study tested the effects of soil temperature, pH and moisture on egg development and subsequent longevity of unfed larvae to develop a mathematical model of these processes.

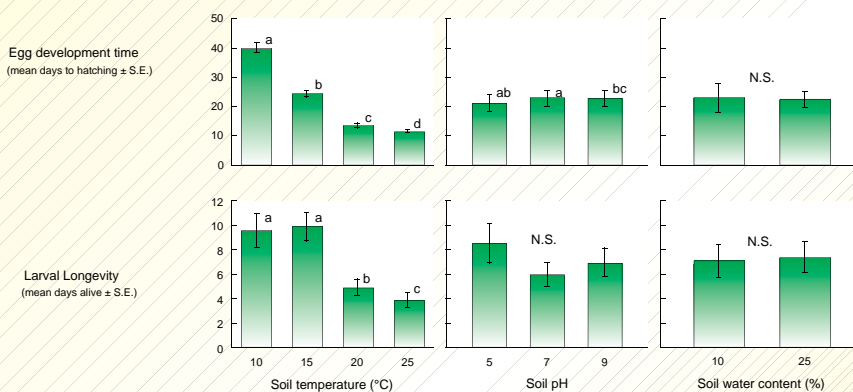


Materials and methods

Freshly laid eggs were incubated in Eppendorf tubes containing soil under a range of different conditions; soil temperatures of 10°C, 15°C, 20°C and 25°C, soil pH 5, 7 and 9 and soil water contents of 0%, 10% and 25%. Tubes were examined daily to record when eggs hatched and the subsequent lifespan of the emergent unfed larvae. Statistical significances were determined using Cox proportional hazards regression models (Cox & Oates, 1984). Results were used to develop a physiologically based model.

Experimental results

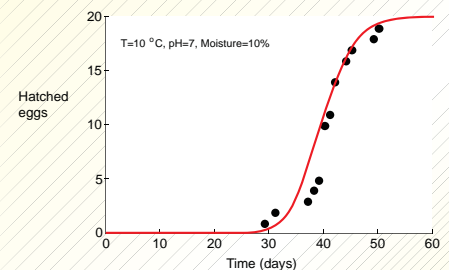
No eggs hatched in the dry soil. In damp soils, temperature had the greatest impact on egg development time with eggs developing faster but larval lifespan decreasing at higher temperatures. Soil pH also had a slight impact on egg development. There was no significant difference between soil water contents of 10% and 25% on either egg development or larval lifespan.



Effects on soil properties on egg development / larval longevity.
Letters indicate significant differences.

Modelling

The Fokker-Planck equation (Jespersen et al., 1999) was developed to model egg hatching and larval lifespan as a single process. Simulations using the model showed close fidelity with experimental results



Example of model simulation (line) and experimental results (circles).

Conclusions

Soil moisture is necessary for *S. lepidus* egg development. Temperature was the most significant factor tested with eggs developing faster, but larvae surviving less time at higher temperatures. An individual based model built on the Fokker-Plank equation permits these processes to be simulated as a single process.

References

- Cox DR & Oakes D (1984) Analysis of Survival Data. Chapman & Hall, London.
- Jespersen S, Metzler R & Fogedby HC (1999) Levy flights in external force fields: Langevin and fractional Fokker-Planck equations and their solutions. *Physical Review*, 59, 2736-2745.