How Soil Properties Affect Egg Development and Larval Longevity of a Grassland Insect Pest - an Empirically Based Model

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Introduction The clover root weevil (*Sitona lepidus* Gyllenhal.) 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 N_2-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 moisture 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 an individual-based model.

Results No eggs hatched in the dry soil (Figure 1). 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 at soil moistures of 10% or 25% on egg development or larval lifespan. The Fokker-Planck equation (Jesperson *et al*., 1999) was developed to model egg hatching and larval lifespan as a single process: simulations showed close fidelity with results (Figure 2).

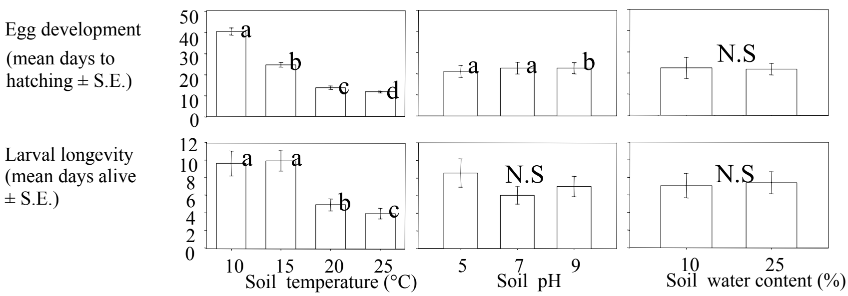

Figure 1 Effects of soils on egg development and larval longevity (Letters indicate significant differences)

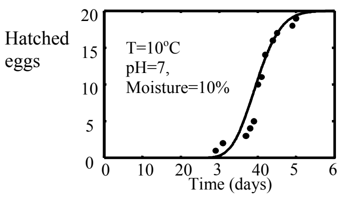

Figure 2 Example of model simulation (line) and experimental results (circles)

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-Planck equation permits these processes to be simulated as a single process.

References

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