

Molting Inhibitory and Lethal Effects of Azadirachtin on the Desert Locust, *Schistocerca gregaria* (Forskål)

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Abstract: Dose-response studies of azadirachtin, dissolved in 90% aqueous ethanol and injected into freshly molted crowded fifth (last) instar nymphs of *Schistocerca gregaria* revealed three kinds of responses: (I) Delay of the next molt and death in the delayed molt, or after apolysis, without being able to escape from the old exuviae; (II) Production of over-aged nymphs surviving up to 83 days without molt or apolysis; (III) Death within 20 days after treatment, without molt, presumably due to a direct toxic effect of the azadirachtin. Solvent injected controls molted to adults within 8-10 days. With increasing doses, response I decreased and response III increased. A dose of $30.4 \mu\text{g g}^{-1}$ (μg azadirachtin per g fresh weight) resulted in response III in all nymphs. A dose of $15.2 \mu\text{g g}^{-1}$ induced the highest proportion of over-aged nymphs, but even with this dose only 13.1% over-aged nymphs were obtained. With doses lower or higher than $15.2 \mu\text{g g}^{-1}$, the proportion of over-aged nymphs was even lower. Over-aged male nymphs exhibited sexual behavior, courting and mounting over-aged female nymphs and adult females, without being able to copulate.

Key words: Azadirachtin, dose-response, anti-molting effect, molt-inhibitory effect, sexual behaviour, desert locust, *Schistocerca gregaria*

Introduction

Azadirachtin, a limonoid found in the Neem tree (*Azadirachta indica* A. Juss), has antifeedant, growth disrupting (also termed molt-inhibitory or anti-molting) and lethal effects on insects (Jacobson, 1986; Aranson *et al.*, 1989; Schmutterer, 1990, 1995; Ascher, 1993; Mordue (Luntz) and Blackwell, 1993; Xuan *et al.*, 2004).

We demonstrated that a finely balanced dose of azadirachtin, administered by injection, inhibits the molt and induces long-surviving over-aged nymphs in the African migratory locust, *Locusta migratoria migratorioides* (Shalom and Pener, 1984, 1987). Other authors also reported on the molt-inhibitory effect of azadirachtin in *L. migratoria* (Sieber and Rembold, 1983; Mordue (Luntz) *et al.*, 1985, 1986). Such over-aged nymphs of this species were utilized to study the interdependence between morphological and physiological metamorphosis; in other words, whether and how inhibition of morphological metamorphosis affects adult competence, that is physiological and behavioral patterns characteristic to adults (Shalom and Pener, 1984, 1987; Pener and Shalom, 1987; Shalom *et al.*, 1988, 1993; Pener *et al.*, 1989; Van der Horst *et al.*, 1989; Wilps *et al.*, 1992).

Although we recorded (Pener and Shalom, 1987) that injection of azadirachtin is capable of producing over-aged nymphs also in the desert locust, *Schistocerca gregaria*, no dose-response relations and their evaluation were published. The present article reports the dose-response data for producing over-aged nymphs in *S. gregaria* and distinguishes between the anti-molting and direct lethal effects of injected azadirachtin in this species of locusts.