The saxaul locust, *Dericorys albidula* Serville (Orthoptera: Dericorythidae), is a major pest of saxaul plants in Qom province of Iran. During 2005-2006, different nymphal instars of bands of *D. albidula* were treated by aerial spraying of *Metarhizium anisopliae* var. *acridum* (Green Muscle®). The gasoline formulation of *M. anisopliae* var. *acridum* isolate IMI 330189 was applied in different conidial concentrations (10^6, 10^7, 10^8, 10^9 and 10^10 spores mL^-1) that were prepared in sterile distilled gasoline. Results showed that various concentrations significantly affected the 2nd, 3rd, 4th and 5th nymphal instars of *D. albidula* compared to control. In addition, there were no differences in the effects of the different concentrations in 2005, but the differences were significant in 2006. Concentration 10^10 killed 100% of tested insects 15 d after treatment. Comparing the results of the two years showed that the susceptibility of nymphs in the second year (2006) was higher than in the first year (2005). In conclusion, the results of this study indicated that the fungal insecticide *M. anisopliae* var. *acridum*, diluted in gasoline, was efficacious with the nymphal instars of locust *D. albidula* in 2005 and 2006.

**Key words:** Saxaul plants, fungal insecticide, nymphal instars, gasoline formulation.

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According to the authors’ knowledge, reports about \( M. \text{anisopliae} \) results in host death between 3 and 4 d after infection (Whitten and Oakseshott, 1991; Starnes et al., 1993). A variety of this species, \( M. \text{anisopliae} \) var. \( acridum \), under the commercial name Green Muscle, has been developed to control locusts and grasshoppers (Thomas et al., 2000). Using oil-based formulations has improved the virulence of conidia and resulted in very promising acridid control (Symmon, 1992; Bateman, 1997).

In this study, we investigated the effect of various concentrations of \( M. \text{anisopliae} \) var. \( acridum \) isolate IMI 330189 with 400 g (2 \( \times 10^{13} \)) viable conidia per liter was used in the experiments. A spray method was used in the toxicity assays. Different conidial (Green Muscle®) concentrations (10\(^6\), 10\(^7\), 10\(^8\), 10\(^9\), 10\(^10\), and 10\(^13\) spore mL\(^{-1}\)) were prepared in sterile distilled gasoline. As a control, gasoline was used. Two-year-old saxaul bushes were cultured in plastic pots (15 cm in diameter and 25 cm height) and 10 1-d-old nymphs were placed on each bush. Ten milliliters of each concentration (fungus diluted in gasoline) and control group were sprayed on bushes. The mortality was recorded after 15 d from treatments. The experiments were repeated three times. This method was performed for various nymphal instars (2\(^{nd}\), 3\(^{rd}\), 4\(^{th}\), and 5\(^{th}\)).

Data analysis
The data obtained were submitted to a one-way ANOVA (\( P < 0.05 \)) after checking for normality. Means were compared by Tukey’s Studentized Range Test, admitting significant differences at \( P < 0.05 \). SAS software was used for all analyses (SAS Institute, 1997).

RESULTS

Insecticidal effect of \( M. \text{anisopliae} \) on \( D. \text{albidula} \) in 2005
Figures 1-3 show the effect of various concentrations of \( M. \text{anisopliae} \) var. \( acridum \) on the 3\(^{rd}\) (Figure 1) 4\(^{th}\) (Figure 2) and 5\(^{th}\) (Figure 3) nymphal instars of \( D. \text{albidula} \) in the first year (2005). Figure 1 reports that various concentrations (10\(^6\), 10\(^7\), 10\(^8\), and 10\(^9\)) significantly affected the 3\(^{rd}\) nymphal instars of \( D. \text{albidula} \) compared to control. In addition, the effect of concentrations was not different (\( df = 5, 12, F = 10.47, P = 0.0004 \)). Concentrations 10\(^8\) and 10\(^10\) had a significant effect on the 4\(^{th}\) nymphal instars of \( D. \text{albidula} \) (Figure 2). There were no differences among these concentrations (\( df = 2, 6, F = 108, P < 0.0001 \)). Comparison of toxicity of different concentrations of \( M. \text{anisopliae} \) var. \( acridum \) on the 5\(^{th}\)
nymphal instars of *D. albidula* indicated that nymph mortality rates at all concentrations (10⁶, 10⁷, 10⁸, 10⁹, and 10¹⁰) were significantly higher than for the control (Figure 3). The toxicity levels of the various concentrations were different but not significant (*df* = 5, 12, *F* = 15.54, *P* < 0.0001).

**Insecticidal effect of *M. anisopliae* on *D. albidula* in 2006**

Nymphal mortality of *D. albidula* exposed to *M. anisopliae var. acridum* in 2006 is shown in Figures 4-7. Effect of conidial concentrations on the 2nd nymphal instar of locust showed that all concentrations (10⁶, 10⁷, 10⁸, 10⁹, and 10¹⁰) significantly increased mortality of nymphs. Furthermore, there were differences in the insecticidal ability of various concentrations. Concentration 10¹⁰ killed 100% of tested insects (Figure 4) (*df* = 5, 15, *F* = 238.66, *P* < 0.0001). Figure 5 shows the mortality trends (to specify the increasing or decreasing trends) of the 3rd nymphal instar of *D. albidula* after treating by *M. anisopliae var. acridum*. There was a significant difference between control and all concentrations. As well, the concentration of 10¹⁰ caused the highest mortality (100%). Other concentrations also showed high toxicity on the 3rd nymphal instar (Figure 5) (*df* = 5, 12, *F* = 71.62, *P* < 0.0001). The efficacy of conidia of *M. anisopliae var. acridum* on the 4th instars of locust can be observed in Figure 6. All of the tested concentrations significantly affected the *D. albidula* nymphs. The highest mortality was observed in the concentration of 10¹⁰ and 10¹³ (Figure 6) (*df* = 5, 12, *F* = 76.62, *P* < 0.0001). *M. anisopliae var. acridum* in the various doses caused significant mortality of the 5th nymphal instar of *D. albidula*. As well, there were differences among all concentrations (Figure 7) (*df* = 5, 12, *F* = 122.60, *P* < 0.0001).

**DISCUSSION**

In this study, the effect of various concentrations of conidia of *M. anisopliae var. acridum* on different nymphal instars of *D. albidula* was assayed under laboratory conditions over two years. This was the first study of the efficacy of a fungal insecticide on *D. albidula*. The results indicate that *M. anisopliae var. acridum* affects the 2nd, 3rd, 4th, and 5th nymphal instars of this important pest of saxaul plants. In our study, the susceptibility of *D. albidula* nymphs was assessed over 2 yr using similar concentrations. The susceptibility of nymphs was greater in the second year (2006) than in the first year (2005). Unlike our study, Peng *et al.* (2008) researched the effect of *M. anisopliae var. acridum* against oriental migratory locusts, *Locusta*
migratoria manilensis (Meyen) over two years (2002 and 2003) and reported that mortality rates caused by this fungus on the aforementioned locust was relatively similar in both years. In this study, the conidia of *M. anisopliae* var. *acridum* in a mixture of soybean oil and kerosene had a good effect on the locust, *Rhammatocerus schistoceroides* Rehn. Because saxaul plants are not used for food, using petroleum products can be a suitable method of control. In the current study, mortality was recorded after 15 d. Similar to our results Lomer et al. (1997) stated that *M. anisopliae* killed over 90% of nymphs after 15 d. These similar results indicate that 15 d is an adequate period for the fungus to take effect. Lomer et al. found that a dose $10^6$ of *M. anisopliae* var. *acridum* killed 100% of second instar nymphs of *D. albidula*. Magalhaes et al. (2000) stated that a $2 \times 10^3$ concentration of *M. anisopliae* var. *acridum* caused 88% mortality on the 2nd nymphal instar of *R. schistoceroides*. As well, Alves et al. (1999) observed that *M. anisopliae* caused 79-90% mortality of short-horned locust in Africa, Brazil, and Australia. Kassa et al. (2004) examined the effect of Green muscle on *Locusta migratoria* (R. & F) and reported that this compound can be effective on this pest.

**CONCLUSION**

In conclusion, the results of this study indicate that fungal insecticide *M. anisopliae* var. *acridum* diluted in gasoline was highly effective in causing mortality of 2nd, 3rd, 4th, and 5th nymphal instars of locust *D. albidula* in 2005 and 2006. As well, the current report shows that mortality of all stages in the second year (2006) was higher than in the first (2005).

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**LITERATURE CITED**


**PALABRAS CLAVE:** Plantas de Saxaul, insecticida fúngico, estados ninfales, formulación de gasolina.

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