VII.6 *Beauveria bassiana* for Mormon Crickets

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Introduction

The first crops planted by the Mormon settlers in Utah were damaged by the insect now referred to by the common name “Mormon cricket” (Cowan 1990). The Mormon cricket, *Anabrus simplex* Haldeman, is not a cricket at all but a longhorned grasshopper from the family Tettigoniidae (fig. VII.6–1). This pest can reach outbreak levels before Mormon crickets begin migrating into range and cropland. Mormon crickets can cause significant damage when bands of huge numbers of insects move onto cropland in the Western United States (Pfadt 1991, MacVean 1990, Swain 1944). Our studies evaluated the effectiveness of a fungal pathogen, *Beauveria bassiana*, to suppress Mormon cricket populations.

Figure VII.6–1— The Mormon cricket is mainly a pest on rangelands but sometimes moves into planted crops and causes economic damage. (Agricultural Research Service file photo K4797–1.)

How *Beauveria bassiana* Works

Interest in insect–fungi interactions has centered, for the most part, on the pathogenic (disease-causing) nature of fungi and their use as microbial control agents. Unlike other insect pathogens that must be eaten to infect insects, fungi can infect an insect through its cuticle (outer skin). The development of fungi pathogenic to insects typically follows this pattern:

(1) Attachment of an infectious stage (called a conidium or spore) to the insect cuticle,

(2) Germination of the conidium and penetration of the insect cuticle by a germ tube from the conidium,

(3) Growth of the fungus inside the insect body (hemocoel) and eventual death of the insect,

(4) Penetration of the fungus to the surface of the dead insect and formation of conidia (plural of conidium) under conditions of high relative humidity, and

(5) Dispersal of the conidia to locations where they may encounter susceptible insects and start the process again.

Among the insect-pathogenic fungi that follow this pattern of development is *Beauveria bassiana*. It is commonly known as the white-muscardine fungus because of the characteristic white covering of conidia (spores) found on the surface of dead insects. Insect cadavers infected with the fungus are transformed into white, mummified bodies resembling in appearance a bonbon candy (“muscardin” means “bonbon” in French [Steinhaus 1949]).

Isolate of *B. bassiana* for Mormon Cricket

The *B. bassiana* strain used in these studies was originally obtained from Mycotech Corporation in Butte, MT. Mycotech has obtained Environmental Protection Agency registration of this *Beauveria* strain for the suppression of several insect pests, including grasshoppers and Mormon crickets. Mycotech recently developed a solid culture system for the production of *B. bassiana* conidia (Goettel and Roberts 1992). Mycotech prepared and supplied a *B. bassiana* dry conidia powder for the laboratory studies and *B. bassiana* formulated in oil (OF) and in an emulsible suspension (ES) for the 1992 and 1993 Idaho field trials (Onsager et al. 1992, Kemp and Streett 1993).

Laboratory Studies

Conidia were suspended in ES1 and ES2 oil and applied to Mormon crickets as 0.08 µL (microliter) droplets beneath the pronotum (on the thorax) at dosages ranging from 0 to 10^6 spores per Mormon cricket. Mormon crickets were reared individually in plastic cups and maintained in an incubator at 77 °F (25 °C). Mormon crickets were fed every 2 days with romaine lettuce, kale, and wheat bran. Mortality was recorded during feeding, and a damp cotton ball was added to cups containing cadavers. The cadavers were then stored at room temperature for 4–6 days to diagnose *Beauveria* infection by observing the characteristic white muscardine appearance on the insect surface.

The median lethal dose (LD_{50}) is commonly used to assess the infectivity of a pathogen. The LD_{50} for the *B. bassiana* isolate against fifth-instar Mormon crickets at 12 days was 1,000 conidia (fig. VII.6–2). The two oil formulations that were compared in laboratory assays showed no consistent differences in overall mortality or percentage of Mormon crickets with confirmed infections (table VII.6–1).

Four replicates of 200 adult Mormon crickets each were treated with 5×10^5 or 5×10^6 conidia in oil according to the procedures described by Kemp and Streett, 1993. A check preparation consisting of oil without conidia and an untreated control were included for each replicate. Each treatment within a replicate was separated into two groups and reared either individually in an incubator at 77 °F or transferred to field enclosures. Four field enclosures 16 ft^2 (1.5 m^2) for each treatment were stocked with 25 Mormon crickets. Mormon crickets were fed lettuce daily. Counts of Mormon crickets were made for each cage, and cadavers were collected for incubation in cups with a moistened cotton ball to diagnose *Beauveria* infection (Kemp and Streett 1993).

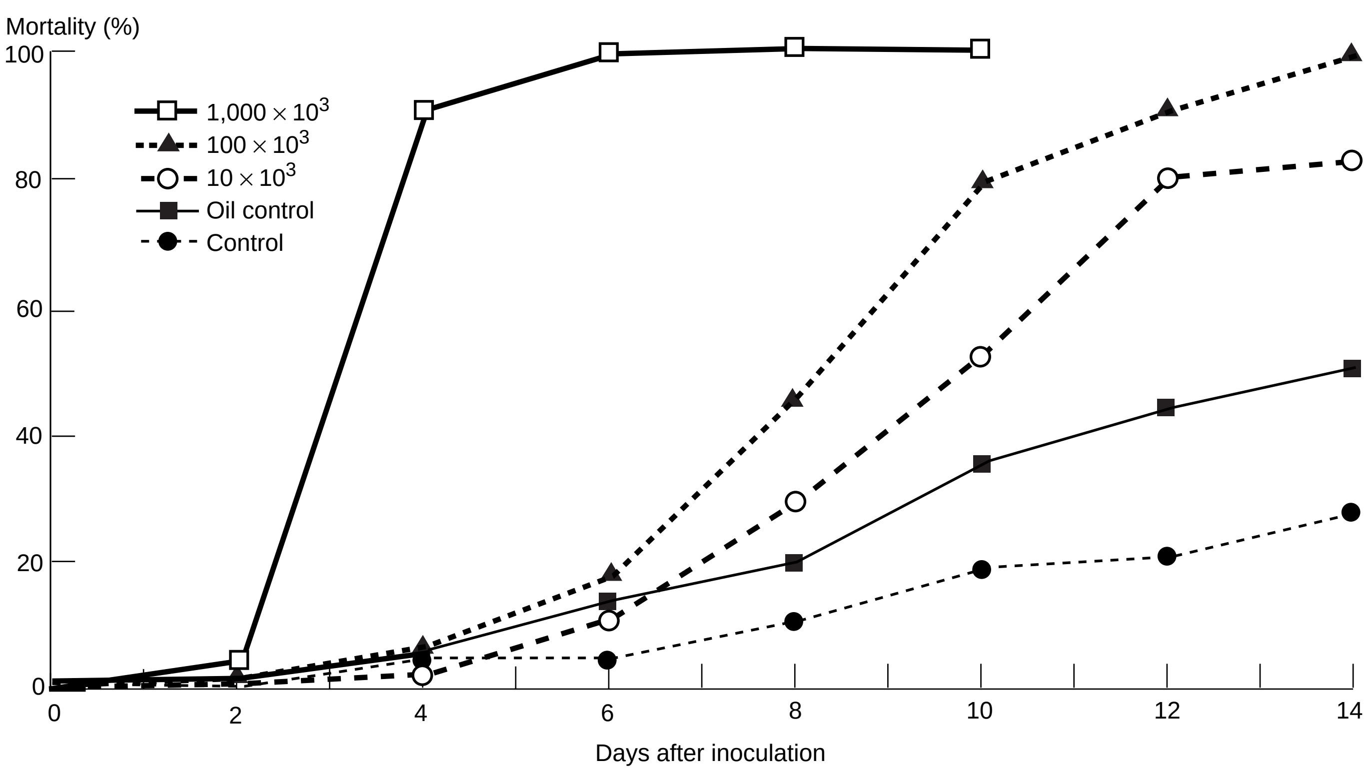

Figure VII.6–2—Cumulative mortality among fifth-instar Mormon crickets in a bioassay of *Beauveria bassiana.*

Table VII.6–1—Laboratory comparison of ES1 versus ES2 oil as a carrier for *Beauveria bassiana.* Cumulative mortality and incidence of infection for Mormon crickets.

	Mortality		Infection	
Dose	[1]ES1	ES2	ES1	ES2
Conidia/ *grasshopper*	— — — — — — *Percent*	— — — — — — —		
0	34	46	8	12
10^2	50	38	20	18
10^3	71	87	42	44
10^4	90	98	65	62

[1] ES = emulsifiable suspension.

Adult Mormon crickets that were inoculated with 5×10^6 conidia per Mormon cricket showed a significant difference in mortality in laboratory versus field cages (fig. VII.6–3). Adult Mormon crickets reared in the field enclosures survived more than 3 weeks longer than Mormon crickets reared in the laboratory. One possible explanation for these results is that Mormon crickets in the field use a behavioral thermoregulation to increase body temperature to a point that restricts fungal development and allows the insect to survive.

Field Studies

Field trials against Mormon crickets were conducted near St. Anthony, ID. Oil (ES1 oil) and clay–oil–water (COW)—100 g clay: 1 liter (L) oil: 2 L water)—formulations were applied at rates of 4.9 (10^{11} and 4.9×10^{12} conidia/acre (1.2×10^{12} and 1.2×10^{13} conidia per ha) and application volumes of 0.9 and 2.7 qt/acre (2.5 and 7.5 L/ha). Each replicate consisted of 10 arenas of 14.4 yd^2 (12 m^2) constructed of aluminum flashing approximately 10–18 inches (25–45 cm) in height. Each arena was stocked with more than 250 Mormon crickets prior to application. Treatments were replicated four times, and treatments within each replicate were applied on the same day (weather permitting) in the sequence outlined by Onsager et al. (1992). An ultralow-volume sprayer (North American Micron) was used for the applications. After application, Mormon crickets were collected from each arena for rearing. Approximately 30–50 Mormon crickets per arena were reared individually in the laboratory; mortality and infection data were recorded as described earlier. Three field cages (16 ft^2/cage) were each stocked with 30–50 Mormon crickets from each arena and covered with chicken wire to keep out birds. Mormon crickets were fed lettuce and sagebrush daily. Mormon crickets were counted daily, and cadavers were collected and incubated in cups with a moistened cotton ball to diagnose *Beauveria* infection.

Results differed somewhat between the formulations that were used in the field. The statistical results suggested that the ES1 formulation produced less mortality but similar rates of infection than the OF formulations at the 2.7 qt/acre application volume. There were no differences in overall mortality or infection rates between the

0.9 qt/acre and 2.7 qt/acre application volumes of oil alone formulations. It should be noted that while the differences in mortality between formulations at the 2.7 qt/acre application volume may have been statistically significant, they were not substantial (80 *v.* 74 percent at the low conidia concentration).

The application rate of conidia had a more substantial impact on both the overall mortality and percentage of confirmed infections. Adjusted for controls, overall mortality averaged 55 percent and 89 percent for the low and high conidia concentrations, respectively. All comparisons between conidia concentrations were statistically significant.

Conclusions

A detailed understanding of the disease dynamics of the *B. bassiana* isolate will be necessary before this product can be considered for use in an integrated pest management program. Gaining this understanding will entail both laboratory and field studies to evaluate short-term and longrange impacts of *Beauveria* on Mormon crickets. The effects of cannibalism, behavioral fever, and host behavior will need further evaluation before the potential of *B. bassiana* as a microbial control agent against Mormon crickets can be determined. Formulation of *B. bassiana* for Mormon cricket control will also require additional research.

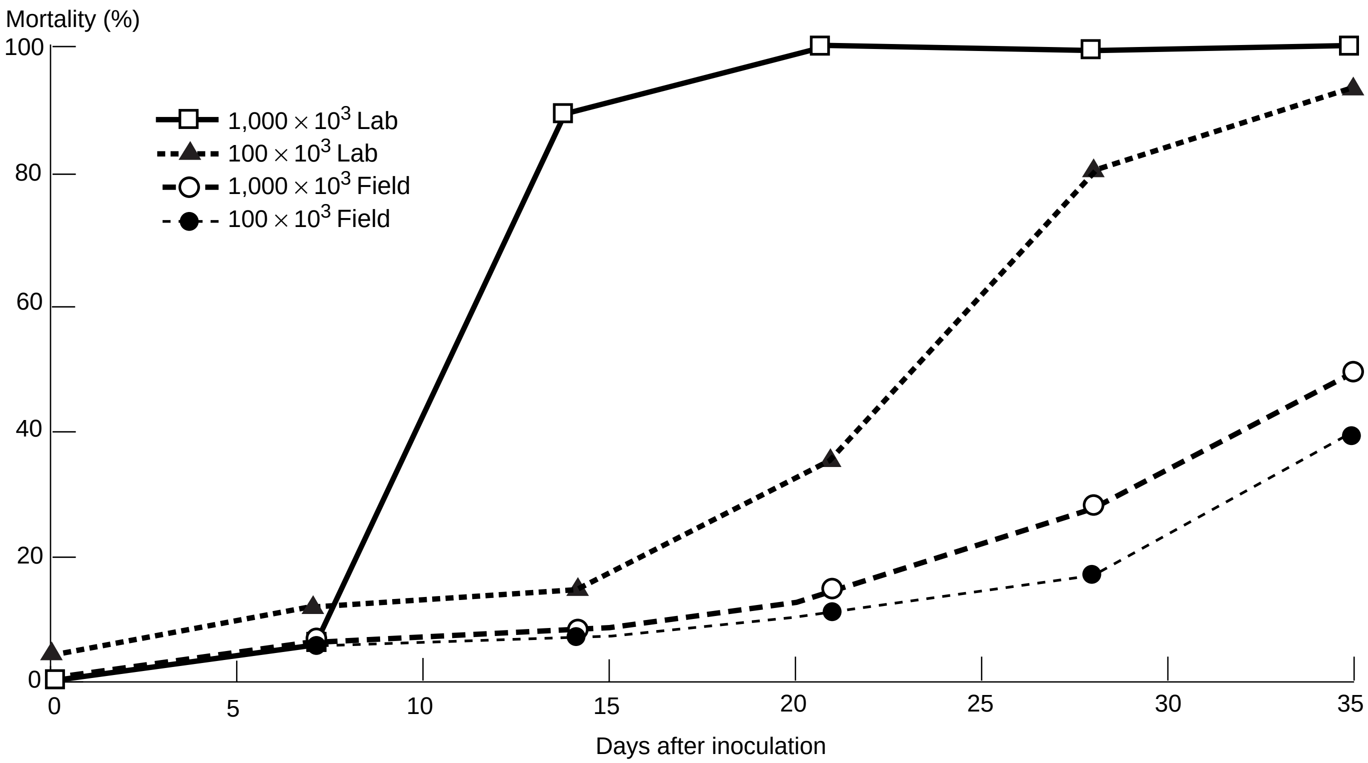

Figure VII.6–3—Cumulative mortality among adult Mormon crickets treated with *Beauveria bassiana* in the lab and reared in the lab or in field cages.

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