I.4 Utility of *Nosema locustae* in the Suppression of Rangeland Grasshoppers

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Editorial note: The authors served as an independent review team and prepared this report on *Nosema locustae* in 1991 at the request of the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine's Grasshopper Integrated Pest Management Project. The internal report contains guidelines and recommendations for the use of *Nosema locustae* and is reproduced in the User Handbook because of the importance of the information the report contains. The present version has been edited to be consistent in style and tone with the User Handbook.

Nosema locustae is a microsporidium pathogenic (disease-causing) to a wide range of grasshoppers (more than 90 species are susceptible). It can be easily mass produced and formulated in baits for use as a biological control agent. Although many species of microsporidia are known to act as important naturally occurring biological control agents of insects, very few can be appropriately used as traditional microbial insecticides.

Laboratory studies, simulation models, and some field experiments suggest that *N. locustae* may be successfully utilized for longrange grasshopper control. But there is little or no evidence that *N. locustae* can be used effectively as a microbial insecticide for short-term control of grasshopper populations.

Inducing infections in insect populations is, at best, difficult. Many variables affect the onset and duration of an epizootic (disease outbreak). In the case of grasshoppers, the number and extent of variables are especially troublesome. The number of grasshopper species present, age of grasshoppers, and population density all influence the outcome of field applications. Therefore, the use of *N. locustae* as a grasshopper biological control agent should be considered as part of a long-term suppression effort but not as a microbial insecticide in direct competition with chemical pesticides.

Diseases that affect insects should have great potential for grasshopper control primarily because many grasshopper species readily eat bait into which pathogens can be incorporated. The extensive information generated by *Nosema locustae* studies will be of great help in this area. Domestic and international efforts should be made to identify and isolate other grasshopper pathogens for use as biological control agents.

In preparation for the analysis that is the foundation for this chapter, we were provided with a number of documents, including representative scientific publications, annual reports, and technical reports (see attached list). In addition, we discussed selected questions with Jerome Onsager, Robert Staten, and Jan Meneley.

After consideration of this information, we made the following specific recommendations:

1. *Nosema locustae* should be used to suppress rangeland grasshoppers in environmentally sensitive areas where cost, rapid knockdown, and high levels of control are not primary concerns. In such areas where insecticidal applications are not possible, continued use of *N. locustae* may be warranted. In these areas it may aid in the long-term management of the pest, and its use may allow researchers to address some of the important ecological questions surrounding it. These subjects are discussed in the following section.

2. Higher rates and/or multiple applications should be used where environmental sensitivities outweigh the higher costs involved.

In most of the past field tests with *N. locustae*, the dosage rate of 1×10^9 spores per acre appears to have been predicated more on the economics involved in a grasshopper control program rather than on the actual dose required for effective grasshopper suppression. As estimates of the number of spores per bran flake at this standard rate of application are considerably below LD_{50} (the dose where 50 percent of exposed individuals are killed) rates for *Melanoplus sanguinipes* and *M. bivittatus*, the effectiveness of higher dosage rates needs further evaluation. Laboratory bioassays support the enhanced effectiveness of *Nosema locustae* at higher dosages, although field studies have produced conflicting results.

In tests with up to five times the standard rate, greater reductions in grasshopper densities have not been obtained. However, in tests with 100 times the standard

rate and where small field cages were also used to evaluate treatment effectiveness, grasshopper mortality was significantly higher, at least with *M. sanguinipes*. Despite the obvious costs of using higher dosage rates, the potential for enhancing the effectiveness of a readily available and registered biological control agent for use in environmentally sensitive areas may outweigh economic considerations.

In these sensitive areas where higher dosage rates and multiple applications of spores may be used, the methods of evaluation should be improved to include confinement of known numbers of the various grasshopper species in laboratory and field cages. Thus, along with monitoring population densities at appropriate time intervals in field plots, known numbers of treated and untreated grasshoppers should be confined in small field cages on untreated rangeland as well as under laboratory conditions. This evaluation plan will allow more accurate estimates of *N. locustae*'s primary effects on infection and mortality rates, as well the secondary effects on grasshopper food consumption, longevity, fecundity (reproductive capability), and vertical transmission.

3. Use of *Nosema locustae* at presently recommended dosages does not reliably provide an adequate level of suppression. *N. locustae* has been shown to induce measurable reductions in grasshopper longevity, fecundity, and consumption rates under controlled conditions in laboratory and field cages. Also, numerous examples from Canada and the United States indicate that it is possible to obtain significant reductions in grasshopper numbers and damage under field conditions using *Nosema.* However, results are not consistent. Reports of apparent failure also exist and many of the "testimonial-type" data are suspect. Reasons given for the apparent failure of *Nosema locustae* to suppress grasshoppers include

    a. Suboptimal applications of the product: low-quality spores, bad weather, equipment failure, etc.

    b. Poor targeting of the product: grasshopper species of low susceptibility or in the wrong development stage.

    c. Incorrect assessment of the product: inadequate sampling or poor experimental design.

    d. Unreasonable expectations of the product: applicators, evaluators, and land managers expect insecticidal activity from a product that inherently cannot provide rapid or high levels of control.

As long as there are available insecticides that do provide high levels of control (70–95 percent is normal), control by *N. locustae* (30–40 percent under the **best** of conditions) will appear inadequate to ranchers and others concerned with economical, reliable grasshopper suppression. Until the basis for the inconsistencies is better understood, *N. locustae* should be reserved for areas where high levels of control are not essential, or where chemical insecticide usage is not a viable option.

If *N. locustae* is used in ecologically sensitive areas, then research should be conducted to determine the stability characteristics of the formulated bran product. Although data in the literature support the conclusion that the *N. locustae* inoculum is active at the time of formulation, nothing in the literature describes the viability of the *N. locustae* formulations just prior to aerial application.

Pathogens that affect insects are markedly sensitive to elevated temperatures, and significant reduction of activity occurs at temperatures as low as 104 °F (40 °C). If no special handling of the *N. locustae* formulation is routinely done as part of the application program, it is conceivable that the bran formulation could be exposed to temperatures during transit and site storage which could cause a significant, serious biological degradation of the product. It is possible that, in several of the studies, site storage conditions could have had a severe negative effect on the formulation.

Therefore, the committee suggests that a thermal death time-study be developed for the *N. locustae* formulation and storage parameters be defined for the product. These steps will ensure that, if and when future applications are made, shipping specifications and site storage requirements of the formulations can be adjusted to preserve the material's efficacy. With handling protocols in place, the viability of the product can be assured up to the point of application.

In addition, bioassays of samples of the *N. locustae* bran formulation from the aircraft hopper should accompany each application. Information from these assays will aid in determining if the formulation was shipped and stored under the proper conditions as specified by data obtained from the thermal death time-study.

Additional research on application techniques other than bait seem warranted given the dearth of information in the literature. In particular, conventional low-volume and ultralow-volume liquid applications, with various adjuvants (additives) to increase droplet deposition and decrease evaporation, should be investigated.

Nosema locustae References

Availability note: Several of the following citations come from annual reports prepared for the Grasshopper Integrated Pest Management Project but not distributed outside the Animal and Plant Health Inspection Service. Individual photocopies of these materials are available on request from USDA, APHIS, Plant Protection and Quarantine, 4700 River Road, Riverdale, MD 20737.

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