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Efficacy of *Beauveria bassiana* and *Isaria fumosorosea* against *Eublemma amabilis* (Noctuidae: Lepidoptera): A predator of lac insect, *Kerria lacca* (Kerr)

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Abstract
An experiment was conducted to determine the effect of *Isaria* and *Beauveria* on larva and pupa of *E. amabilis. Beauveria bassiana and Isaria fumosorosea* are entomopathogenic fungi used as biological control agents for *E. amabilis.* Both have been used as mycoinsecticides providing a good biological alternatives to conventional methods. The *Isaria* was found to have a mortality factor of 80% after 3 days of treatment and *Beauveria* showing 40% mortality factor. Similarly, *Isaria* was proved to be effective on pupal stages of *E. amabilis* showing 70% mortality factor followed by *Beauveria* with the relatively low mortality factor of 30%. More studies would be necessary to help identify interactions between microbes and natural enemies to increase and enhance opportunities and further develop biological pest control programs.

Keywords: *Beauveria bassiana, Isaria fumosorosea, Eublemma amabilis*

Introduction
The entomopathogenic fungi *Beauveria bassiana* and *Isaria fumosorosea* (*Paecilomyces fumosoroseus*) have been used as mycoinsecticides providing biological alternatives to chemical insecticides. Biological control of pests by natural enemies is important for ecosystem service delivered to agriculture worldwide. They have been individually evaluated under laboratory, greenhouse and field conditions. Management of pest in lac cultivation poses a unique problem emerging from very close association of the lac insect, *Kerria lacca* (Kerr) (Hemiptera: Tachardiidae) and its most destructive predator, *Eublemma amabilis* (Moore) poses a problem with not only the standing lac crop but also with the stored lac. Approximately 1000 entomopathogenic fungal species are known to kill insects (Shang *et al.*, 2015) [1] and about 100 mycoinsecticides are commercially registered worldwide (Jaronski, 2010) [2]. *B. bassiana* is a cosmopolitan fungi found on infected insects in both temperate and tropical regions. This hyphomycete fungus with contact activity has been employed worldwide with success, and interest in its use has increased as evidenced by the number of commercial products available and under development (Butt *et al.*, 2001) [3]. Habitats for *B. bassiana* range from desert soils to forests and cultivated soils and has been isolated from insects of diverse orders. Generally, germination of *B. bassiana* conidia starts after about 10 hrs and completed in 20 hrs at 25 ºC. The fungus *Isaria fumosorosea* produces enzymes that weakens the insect's defense mechanisms and pathogenesis it from within. Like most entomopathogenic fungi, it infects its host by breaching the cuticle. Susceptible insects exposed to blastospores and conidia of *I. fumosorosea* show declined growth and high levels of mortality. A mycopesticide kills insects as a result of the insect coming into contact with the spores either by spray droplets or by walking on a treated surface. Once the fungal spores attach to the insect's cuticle, the fungus spores penetrate into the insect's body; it takes several days for infected insects to die. A wide range of insecticides, acetamiprid, organophosphates, thiamethoxam, imidacloprid, synthetic pyrethroids, and neonicotinoids, were used for the control of insects different. Overuses of insecticides have developed resistance to insect pest and have adverse effects on non-target pest and human. Biological control of insect pests with entomopathogenic fungi is an alternative to conventional insecticides, safe to plants, humans,

animals (Khetan, 2001) [4] as well as non-targeted insects (Loc *et al*., 2002) [5] (Wu *et al*., 2014) [6]. The present study evaluates the efficacy of the entomopathogenic fungi *B. bassiana* and *I. fumosorosea* with respect to the larva and pupal stages of *E. amabilis*.

Materials and Methods

The present investigation were carried out in Department of Entomology under the network project "Conservation of Lac insect and Genetic resources", AAU, Jorhat, Assam during 2018-2019.

Fungi culture

The entomopathogenic fungi were collected from Department of Entomology, AAU, Jorhat, Assam. Conidia were obtained from a culture on potato dextrose agar (PDA, Britania S.A.) maintained for 10 days at ±25°C in incubator. The PDA was melted before use and 60 µg/ml of antibiotic, Streptomycin was added in the media.

Bioassay: Pathogenicity test

The larva and pupa of *E. amabilis* were collected from the Lac laboratory, Department of Entomology, AAU, Jorhat, Assam. The pathogenicity of *B. bassiana* against larvae and pupae of the predator *E. amabilis* were evaluated by aspersion technique. The conidia for the bioassay tests were harvested from the two week old cultures of *B. bassiana* and *Isaria fumosorosea* by washing the surface of the plates with 75-100 ml of sterile distilled water containing 0.02 % Tween-80. The graded concentrations of the EPF were prepared by following serial dilution technique. Treated insects were sprayed with 300 µl of a conidial suspension of 1×10^7conidia ml^{-1}, with a 35 ml glass atomizer, while the control insects were sprayed with 300 µl of 0.01% (v/v). Insects were treated and placed in a petri dish with sterile filter paper to dry the excess inoculum. The starved larvae and pupa are transferred to the petri plates containing 10 test larvae/petri plate and 10 test pupas /petri plate in four replications for each test entomopathogenic fungus. The petri plates were then sealed with parafilm and kept in the incubator (±28 ºC) and mortality data were recorded at 24, 48 and 72 hours after treatment (HAT).

Results and Discussion

The *Isaria* and *Beauveria* are the promising biocontrol agents used in insect control. The larva was highly affected by the *Isaria* as compared to *Beauveria*. There was a white fluffy appearance on the larva body which covered the whole body like a cottony mass structure. The larva mortality increases as the days increases and *Isaria* proved to be the most effective. It was also observed that the treated larva has some swollen appearance. The *Isaria* was found to have a mortality factor of 80% after 3 days of treatment. There was also white cottony appearance on the larva treated with *Beauveria*. *Beauveria* proved to be least toxic as compared to *Isaria* and recorded mortality factor of 40% after 3 days of treatment. Similarly, the pupa was highly infested by the *Isaria* as compared to *Beauveria.* There was a change on the pupal body after the treatment and pus like structure can be seen. The mortality increases as the days increases and *Isaria* proved to be the most effective. The *Isaria* recorded mortality factor of 70% after 3 days of treatment. Likewise, the *Beauveria* infested can also be seen on the larval body. There was no mortality on the 1st day after the treatment. The body was covered with little cottony white structure and there was no adult emerged. The *Beauveria* was found to have mortality factor of 30% after 3 days of treatment.

(Bugti *et al*., 2018) [7] studied the pathogenicity of *Beauveria bassiana* strain 202 (Bb-202) against multiple targeted sucking insect species that are serious pests of crops and ornamental plants. The present results are also in close conformity with findings of (Batcho *et al.,* 2018) [8] who studied the effects of five *Beauveria bassiana* strains on cabbage moth *Plutella xylostella.* Also, (Hussein *et al*., 2016) [9] evaluate the *Isaria fumosorosea* CCM 8367 and *Steinernema feltiae* Ustinov against immature stages of the Colorado potato beetle. (Sabbour and Singer, 2013) [10] studied the efficacy of *Paecilomyces carneus* and *Paecilomyces farinosus* against the corn pests under the laboratory and field condition which are found similar with the findings. Similarly, (Sabry, 2011) [11] also studied the efficacy evaluation of *Beauveria bassiana* and *Metarhizium anisopliae* on some insect pests under laboratory conditions. Likewise, laboratory evaluation of *Isaria fumosorosea* CCM8367 and *Steinernema feltiae* against immature stages of the colorado potato beetle were evaluated (Hany *et al*., 2016) [12]. (Ana *et al*., 2017) [13] also observed interactions between the *Beauveria bassiana* and the Neotropical predator *Eriopis connexa*.

Conclusion

As the use of insecticides causes health hazards, resurgence, environment contamination so it is important to study the use of bio-control agents for the insect control. The *Eublemma amabilis* is the serious pest of *Kerria lacca* and the need for the control is important. The *Isaria* proved to be the most effective biocontrol agents and is effective both the larval stages and the pupal stages. Thus, we can conclude that *Isaria* is a prospective bio-control agent against immature stages of *E. amabilis.*

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