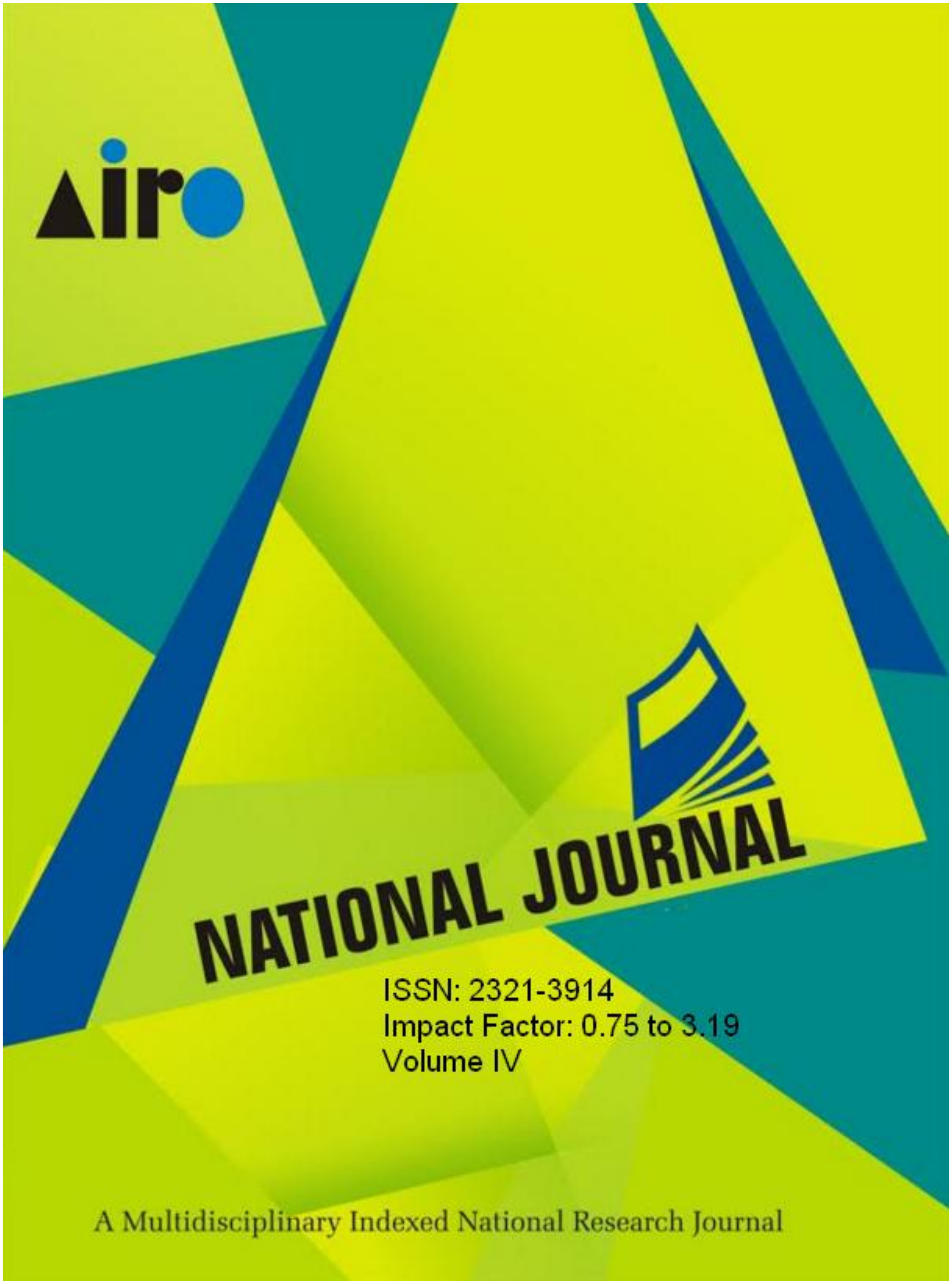
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EFFICIENCY OF DERMAPTERAN INSECTS AS BIOLOGICAL CONTROL AGENT

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ABSTRACT

High populations in plant rhizospheres in terms of R/S (rhizosphere to nonrhizosphere) ratios may range from 2:1 for total protozoa to 20:1 for some species. Generally, bacteria and yeasts are preferred food sources for protozoa but they can also feed on some fungi. Thus, certain species of mycophagous amoebae in agroecosystems can destroy a sufficient quantity of pathogenic fungal propagules to induce significant biological control of specific root diseases.

KEYWORDS: *Soil, Flora, Fauna*

INTRODUCTION

The Collembola are the most abundant and important of the orders of primitive insects in the Apterygote. They are well represented in agricultural soils to 15 cm depth and may migrate to much greater depths, depending upon soiltype, moisture and cropping practices. Collembola and other invertebrates that feed on the microflora are not uniformly distributed in the soil but tend to congregate around living, dead or dying roots and organic matter where food sources are most abundant. The rhizosphere factor is important in relation to microarthropod potential to challenge plant pathogens at the infection site. Laboratory tests showed that Collembola are attracted to cotton roots, particularly in slowly drying soil.

The soil inhabitants include the seed and root infecting pathogens such as the damping off causing Rhizoctoniasolani and surviving propagules of foliar pathogens such as C. beticola and Streptomyces scabie which may survive sometimes for several years in the soil. The basis for biocontrol of soil inhabiting plant pathogens is the interaction among the antagonists and pathogenic inhabitants.

The first three types of relations, namely competition, antibiosis and mycoparasitism occur commonly between flora and growth of one or both interacting organisms are adversely affected. Both interacting organisms are adversely affected by competition, thus resulting in reduced growth of both organisms. This may be due to competition for limited resources.

Under antibiosis, organic products of one microorganism are detrimental to growth or metabolic activities of another organism. Under parasitism one organism establishes a long term relationship with a host from which it derives nutrients and frequently, death does not occur immediately. In some cases, the parasitism does not result in the death of the host. These relations are common when the biological agent is a member of the microflora. On the other hand, predation results in the death of the host within a short period of time. Under amensalism, one interacting partner is adversely affected while the other is not affected.

Spodoptera frugiperda Smith is considered as the most important pest of maize in almost all tropical America. In Argentina, the earwig Doru lineare Eschscholtz (Dermaptera: Forficulidae) has been observed preying on S. frugiperda egg masses in corn crops, but no data about its potential role as a biocontrol agent of this pest have been provided. The predation efficiency of D. lineareon newly emerged S. frugiperda larva was evaluated through a laboratory functional response study. D. lineare showed type II functional response to S. frugiperda larval density, and disc equation estimations of searching efficiency and handling time were (a) = 0.374 and (t) = 182.9 s, respectively. Earwig satiation occurred at 39.4 S. frugiperda larvae.

The fall armyworm, Spodoptera frugiperda Smith (Lepidoptera: Noctuidae), is an important pest of many crops, causing important yield losses in different regions of the Americas. In northern Argentina, S. frugiperda infestations may result in maize yield losses between 17% and 72%. To date, control of this pest relied mainly on the use of synthetic pesticides and as a result, individuals resistant to insecticides have been selected.

Resistance of S. frugiperda to various carbamate, organophophorus, and pyrethroid insecticides has also been observed in field strains collected from corn in north, central and south Florida.

S. frugiperda is a native pest in Argentina with a diverse complex of natural enemies. The impact of parasitoids on these populations has been well studied. In turn, some work has focused on entomopathogenic organisms such as nuclear polyhedrosis virus, Nomuraea rileyi, Metahrizium anisopliae and Beauveria bassiana. However, there is a remarkable lack of information on the role of natural predators. A few exceptions are technical reports on the action against this pest by some carabid beetles and other Coleoptera, lacewings (Neuroptera), and some bugs (Heteroptera).

Both D. luteipes and D. lineare species have been found in maize crops in northern Argentina, although their role in the agroecosystem is still unknown. In Tucumán province, during summertime, D. lineareshow evidence of foraging activities through the day. This earwig previously was reported preying on S. frugiperda egg masses in corn crops.

Because S. frugiperda is considered a key pest of corn in northwestern Argentina and because D. linearepopulations frequently occur in the field, it needs to be determined if this species acts as a predator and should be considered a potential biological control agent. The aim of this study was to investigate the predation efficiency of this earwig through its functional response to S. frugiperda newly emerged larvae in the laboratory.

RESEARCH WORK

An interesting trait of the flora is the continuously altering of their roles as pathogens or biological agents and extensive interactions within and outside of the floral group. It is thus not unusual to control a bacterium with another one and even non-pathogenic isolates of a pathogenic species are sometimes applied to control a pathogenic isolate.

Control of soil inhabiting plant pathogens with the soil bacteria has often been considered in association with either the spermosphere or the rhizosphere and less for the bulk soil, where in the rare cases, studies have focused on comparison to the spermosphere or the rhizosphere bacteria. There have been extensive reports of control of bacterial pathogens with other bacteria. For example, Pseudomonas fluorescens was applied to control Erwinia carotovora and soft rot of potato.

Trichoderma harzianum, like other species within the genus, has been used to control various pathogens on a number of crops. Some examples are presented in the following when application of T. harzianum suppressed R. solani and damping-off on radish, damping-off of snap beans, collar-rot of coffee, seed rot and stem and root lesions on beans and also resulted 86% reduction of R. solaniinoculum potential in naturally infested soil.

Ever since then, the fauna have increasingly been recognized as potential suppressants of plant pathogens. Most of the research efforts on control of soil inhabiting pathogens with the fauna have focused on fungal pathogens. Viable propagules of Gaeumannonycesgraminis var. tritici (take-all disease pathogen) decline more rapidly in "diseases suppressive soils" (Schneider, 1982) than in non-suppressive soils.

The nature of antagonism of soil inhabiting plant pathogens by the fauna is direct predation (feeding). Micro- and mesoscopic species of soil fauna depend to a large extent on microflora as food sources in the rhizosphere and during organic matter decomposition. This creates an opportunity for the consumption of the pathogens and their propagules with resultant reduction of inoculum potential.

S. frugiperda larvae were placed individually in glass tubes (12 cm high × 1.5 cm diameter) with host leaves and carried to the laboratory. Adults of S. frugiperda were maintained in polyethylene-terephthalate cylindrical cages (30 cm high × 10 cm diameter). For aeration, the top was covered with a nylon mesh cloth. These cages contained pieces of paper that allowed females to rest and to lay eggs. Food was provided via a cotton wick saturated with a honey and water solution (1:1 vol/vol). Cages were checked daily for egg masses, and these were collected and deposited in glass tubes as above. Upon eclosion the neonate larvae were placed in 250 cc plastic pots containing artificial diet.

Earwig colonies were maintained in plastic cages (30 × 25 × 8cm) containing pieces of corrugated cardboard as refuge. Commercial cat food and a cotton wick saturated with a honey + water solution (1:1 vol/vol) were provided as food. In each cage, a maximum of 20 couples were maintained together to prevent cannibalism. Cages were examined daily, and eggs were transferred carefully with the female to a 250 cc plastic pot and provided with a plastic soda cup filled with wet cotton (1.5 cm high - 3.0 cm diameter). Normally, females transported their offspring into the soda cups. Ten days after nymphal eclosion, they were transferred to larger plastic cages (as described above) until they completed development.

Insect cultures were conducted in the laboratory at 26 ± 2°C, 14:10 (L:D) photoperiod, and 70 ± 10% RH. All predatory individuals used in the experiments were reproductively active females of D. lineare that were two to three weeks old. Females were starved for 48 h before trials and were randomly collected from the breeding cages.

Handling time of newly emerged S. frugiperda larvae is defined in this study as the time interval starting with the piercing of larval tegument until the complete consumption of the prey item, excluding the cephalic capsule. Preliminary observations showed that sometimes earwigs do not consume the cephalic capsule.

Handling time was assessed by direct observation under stereoscopic microscope and measured with chronometer. Each female of D. lineare (n = 100) was placed with 5 to 10 larvae in a 6 cm (diameter) by 0.5 cm (depth) Petri dish. The trials were run at 26 ± 2°C.

Potted corn plants (2nd vegetative stage) covered with a polyethylene-terephthalate cylindrical cages (35 cm long × 18 cm diameter) were used as the experimental arenas. Each cage was covered with a fine nylon mesh allowing air exchange.

DISCUSSION

Combinations of two or more biological control agents which are compatible at the target environ such as spermosphere-soil interface, the root-soil interface or the bulk soil should provide enhanced protection from pathogen activity. Some strains of Fluorescent pseudomonads when combined in greenhouse, growth chamber and field tests resulted in enhanced suppression of take-all Gaeumannomycesgraminis var. tritici an d improved wheat growth.

Soil inhabitants, microflora and micro- and mesofauna provide an enormous potential for natural suppression of inoculum, disease incidence and severity. The key to understanding the phenomena and the associated potential lies in understanding the soil as an ecosystem and interactions among the potential antagonists and the target pathogens. Current research has concentrated on the rhizosphere in particular and to some degree on the spermosphere. Understandably these research efforts have been directed specifically at soilborne pathogens, disregarding other soil inhabiting pathogens in the bulk soil.

Some of these toxins may well serve to provide protection against potential enemies and thus the algae may serve as antagonists against some soil inhabiting plant pathogens.

Productions of toxic metabolites are not limited to antagonists but are also products of pathogens and may well provide protection from antagonists. Successful antagonism against such pathogens may require ability to detoxify these protective toxins by applied agents, as observed with L. arvalis.

Predation rate was determined by releasing a single female earwig on potted corn plants that contained newly emerged S. frugiperda larvae at different densities: 1, 7, 10, 20, 40, 70, 100, 115, 130, 160, 190, 250, 360, 420 and 500 larvae. Larvae were placed using a paintbrush in the whorl region, and usually most of them spread over the entire plant. So, at the release time, the prey were randomly distributed on the corn plant. After two hours, the predators were removed and the number of remaining intact larvae alive was recorded. Six replicates were done for each prey density, and consumed prey were not replaced.

At the lowest prey density (1 larvae/plant), 66.6 % of D. lineare individuals failed to attack the prey; although, facing up to 10 larvae/plant, all earwigs ate at least 2 of them. In the type II model, as prey density increases, searching for prey becomes a less important limit on the rate of predation. Prey items are easy to locate and rate of consumption is more affected by handling time (i.e., the time it takes a predator to subdue, consume, and digest its prey). As searching becomes less important and handling becomes more important, the rate of consumption shows a decelerating rate of increase. Eventually, search is not limiting at all and the rate of consumption levels off at an upper limit determined by handling time alone.

Generally, the density levels used in laboratory studies are substantially higher that those occurring in the field. However, in this study, densities were realistic, taking into consideration the biology of both the predator and the pest. S. frugiperda eggs are deposited in layers and covered with scales from the female's body. Each egg cluster has an average of 109 ± 98.6 eggs, the eclosion rate is over 95 %, and the larvae remain aggregated on the host plant during the first hours after emergence. According to the findings, a single D. linearefemale may be able to consume almost half the offspring of a single egg cluster.

An estimation of the potential impact of D. lineare predation on the population of S. frugiperda larvae may be generated by combining the results of experiments described here with estimates of earwigs and pest larvae densities in situ. Although the dynamics of generalist predators are not tightly coupled to those of any one of their prey, such predators can have dramatic effects on prey populations.

Clearly, predation by D. lineare on S. frugiperda larvae may significantly influence survival to the larval stage in this pest. However, in functional response studies, field data are an essential complement for the laboratory results because in natural conditions other variables can interfere in predator behavior. The performance of this earwig as a potential biocontrol agent can only be appreciated when considering all relevant aspects of its biology, including development and reproduction.

CONCLUSION

The ability of the archaea to thrive in extremely harsh environments may be indicative of their competitive ability. It is therefore feasible to explore these organisms for any potential to control soil inhabiting plant pathogens.

While no information is available on control of bacterial pathogens with fungal antagonists, information is available on control of bacteria by fungi, recent studies have shown that cercosporin, produced by Cercospora spp. can inhibit growth of E. coli. This observation presents an opportunity to explore the possibility of applying some fungal antagonists and their metabolic products to control bacteria and other soil inhabiting pathogens.

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