Ecological Distribution of Soil Microarthropods and Their Role in Plant diseases Suppression

A Thesis

Submitted to Zoology Department, Faculty of Science, Tanta University in partial fulfillment of the requirements for the award of M.Sc. Degree in Zoology
(Ecology)

Presented by

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التوزيع البيئى لمفصليات الأرجل الدقيقة فى التربة ودورها فى مكافحة أمراض النبات

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مقدمة من

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بكالوريوس علم الحيوان 1999

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To whom it may concern

This is to certify that / Mohamed Fouad El-Sayed Ageba had attended and passed successfully the following postgraduate courses as a partial fulfilment of the requirements for the degree of Master of Science (zoology) during the academic year 2000 -2001.

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Contents

Introduction and aim of the work

Crop losses to pests, pathogens and weed competition exceeded 40% worldwide in 1989–90 (Oerke *et al*.,1994) ranging from 28% in Europe to almost 49% in Africa. Wide spread use of pesticides like fungicides, herbicides and insecticides are used in managing different groups of pests to maximize crop production.

In 2004 the market value for chemical crop protection products rose by 15% in nominal US dollar value to reach $30,725 million. The sales of fungicides globally increased to 27.6 % from 2003 to 2004 (Annual Report 2004/2005 of Crop Life International AISBL). In Egypt fungicides imports in 2003 were $ 5.330 million (Arab Agricultural statistics, year book, 2004)

Although pesticides are credited with success in increasing food production and helping to protect man and animals against disease vectors, only a small percentage of the applied pesticides reach the target pests, this is estimated to be less than 0.1 per cent (Pimentel and Levitan, 1986). Thus, more than 99 percent of applied pesticides usually reaches the soil, even if sprayed on the growing crop, and so may have an effect on non target organisms living in the soil.

One of the most important biological issues that these pesticides may deplete the major biotic components of the rhizosphere include the microflora and the micro/mesofauna which, through their complex interactions, create an environment that may be either conductive or suppressive to plant growth, health and function. They play a primary role in the degradation of plant and animal residues and other organic matter in the environment. Anything that affects their activities might affect the function of soils not only in crop production, but also in the global carbon and nitrogen cycles and in the removal of a range of environmental pollutants.

Pesticide residues usually occur in the top 15 cm layer of soil (Lichtenstein 1962, Harris and Sans 1969). It is also the region of greatest activity of soil fauna and flora (Alexander, 1961), and provides a platform for interaction of pesticide residues with them.

Generally, these pesticides provide a significant benefit to agriculture and public health. At the same time, pesticide use is causing major problems: (1) Approximately 20.000 fatalities occur worldwide annually. (2) Large amounts of food products are contaminated. (3) Beneficial natural biota are destroyed. (4) The injurious effects to terrestrial environments include reduced (a) stability, (b) energy flow, (c) species diversity, (d) pollination, and (e) waste decomposition and cycling.

Soil-borne diseases result from a reduction of biodiversity of soil organisms. Restoring beneficial organisms that attack, repel, or otherwise antagonize disease-causing pathogens will render a soil disease-suppressive. Plants growing in disease-suppressive soil resist diseases much better than in soils low in biological diversity. Beneficial organisms can be added directly, or the soil environment can be made more favorable for them.

The concept of suppressive soils was described by Baker and Cook (1974) in their first book on the biological control of plant pathogens. This treatise described suppressiveness as the ability of a soil to prevent, truncate or delay the development of a disease even though favorable environmental conditions exist. Further research has attempted to explain the actual mechanisms of disease suppression.

These studies have looked at the influences of various microbial antagonists, soil fungistasis (inhibition of fungal growth), and physical and chemical properties of soils. Investigations into the role of soil fauna in this process are relatively new.

Many species of Protozoa, free-living nematodes, and microarthropods (Acarina and Collembola) are microphagous or specifically mycophagous and capable of modifying the natural rhizosphere microflora. Recently, the potential of these animals as plant-pathogen deterrents has been recognized

Microarthropods (Acarina and Collembola) as root-pathogen deterrents have come under serious investigation only recently, although examinations of the gut contents of these animals have, for many years, labelled them as very active fungal feeders. Indeed, it has been suggested that the ability of many Acari species to feed on higher plants (phytophages) may have evolved from the feeding on fungi (Krantz and Lindquist, 1979). The Cryptostigmata, or oribatid mites, are largely nonpredatory saprophages or mycophages, the latter preferring pigmented fungi (Mitchell and Parkinson, 1976), which are otherwise highly resistant to adverse conditions in field soil. This suggests a potential for destroying such pigmented pathogens as *Rhizoctonia solani* and *Cochliobolus sativus;* however, most attention to mite activities in managed agricultural systems has been directed at the phytophagous economic pest species, or at saprophages as possible spreaders of pathogen propagules and disease (Beute and Benson, 1979).

Therefore, it is important to study the possible effects of specific agriculture practices on soil non target organisms.

The focus of the research presented in this thesis is to

(1) Assess the effect of application of two chemical fungicides and two biocides commonly used in Egypt, on the distribution and population structure of soil oribatid mites.

(2) Explain the role of oribatid mites *Scheloribates pallidulus* and collembolan species, *Hypogastrura inermi*s in suppression of soil borne pathogenic fungus, *Rhizoctonia solani*, which causes damping off disease of cotton seedlings in a laboratory experiment.

Review of literature

Microarthropods are among the most abundant decomposers in soil. Acari and Collembola are a main constituent of the biomass of microarthropods in soils. Oribatid mites (Acari, Oribatida), as part of the microarthropod community, reach densities of up to 400,000 individuals/m^2 in temperate forests. They comprise about 10,000 described species worldwide (Schatz, 2002).

General Ecology of Oribatid mites

Oribatid mites are actively involved in decomposition of organic matter, in nutrient cycling and in soil formation. All active instars of these mites feed on a wide variety of material, including living and dead plants and fungi, moss, lichens and carrion; many species are intermediate hosts of tapeworms, some species are predaceous, none is parasitic (Krantz, 1978). Oribatida influence decomposition and soil structure by comminuting organic matter; their fecal pellets provide a large surface area for decomposition, and are in turn an integral component of soil structure in organic horizons.

They are the most important group of arachnids from the standpoint of direct and indirect effects on the formation and maintenance of soil structure (Norton, 1990). Oribatid mites disperse bacteria and fungi, both externally on their body surface, or by feeding on spores that survive passage through their alimentary tracts. They can enhance endomycorrnizal colonization (Klironomos and Kendrick, 1995). Many species sequester calcium and other minerals in their thickened cuticle (Norton and Behan-Pelletier, 1991). Thus, their bodies may form important ’sinks’ for nutrients, especially in nutrient limited environments (Crossley, 1977).

The feeding habits of oribatid mites

Oribatid mites are particulate feeders; chelicera and other structures of the mouthparts are used together to cut or tear particles into sizes suitable for intake (Norton, 1990). The feeding habits of oribatid mites are traditionally categorized based on analysis of their gut contents (Luxton, 1979). Macrophytophages (including xylophages feeding on woody tissue, and phyllophages feeding on non-vascular tissue) feed on higher plant material. Microphytophages (including mycophages feeding on fungi, phycophages feeding on algae, and bacteriophages feeding on bacteria) feed on the soil microflora. Panphytophages feed on both microbial and higher plant material, either concurrently, or at different stages in the life cycle.

Walter (1987) noted that many Oribatida that have been considered mycophagous, also graze on algae and act as predators of nematodes; he defined these species as polyphagous.

Siepel and de Ruiter-Dijkman (1993) divided oribatid mites into feeding guilds on the basis of their carbohydrase activity. Herbivorous grazers showed cellulase activity only and can feed on the cell wall and cell content of green plants (both living and dead) and algae. Fungivorous grazers showed chitinase and trehalase activity, and can digest both cell walls and cell contents of living and dead fungi. Fungivorous browsers showed trehalose activity only and can digest cell contents of living fungi. Herbo-fungivorous grazers are able to digest both green plants and fungi. Opportunistic herbo-fungivores can digest cellulose in litter and cell walls of living green plants, and trehalose in fungi. Omnivores show cellulase and chitinase activity and can feed on components of plants, fungi and arthropods. Species which lack carbohydrase activity entirely probably are predators, or carrion feeders and/or bacteria feeders.