Alexandria University
Faculty of Agric. (Saba-Bacha)

BIOLOGICAL CONTROL OF CERTAIN SCALE INSECTS AND MEALY BUGS INFESTING CERTAIN FRUIT TREES

BY

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A thesis submitted in partial fulfillment of the requirements Governing the award of the degree of

MASTER OF AGRICULTURAL SCIENCES

(PESTICIDES)

Department of Plant Protection

From

Alexandria University

2009

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2009

جامعة الإسكندرية
كلية الزراعة . سابا باشا

المكافحة البيولوچية لبعض الحشرات القشرية والبق الدقيقي التي تصيب بعض أشجار الفاكهة

مقدمة من

محمدعبد القو ي عبد الحليم رزق

رسالة علمية مقدمة استيفاءً لمتطلبات منح درجة

الماجستير في العلوم الزراعية
(تخصص مكافحة الآفات)

من

جامعة الإسكندرية

٢٠٠٩

لجنة الإشراف

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ACKNOWLDEGMENT

Thank to **"Allah"** who has lightened my path to accomplish this work. The few words I wrote here can never express my feelings of gratitude. I have for my supervisors and the persons who helped me to achieve this work.

If I am to vote the heartiest thanks, it is to **Prof. Dr. El-Sayed H. M. Tayeb**, Professor of Pesticides Chemistry and Toxicology, Plant protection department, Faculty of Agriculture, Saba Bacha, Alexandria University who I can not possibly cover words of my great appreciation for his great help, faithful effort in supervision during the progress of this work. Also, for his encouragement and critical review with valuable comments which can not be forever denied. Without them, this study would never have been existed.

I would like to express my deepest gratitude and thanks to **Prof. Dr. Moustafa Abdel-Azeim Amer,** Professor. of Plant Pathology Agricultural Botany Dept.,Fac. of Agric., Saba Basha ,Alexandria University **,** for his support, encouragement and critical review with valuable comments on this dissertation, also for his ideal supervision, valuable effort, constant guidance and help to complete this study. He denied no effort for the completion of this work.

Special thanks and great appreciation go to **Prof. Dr. Moustafa Fathallah El-Deeb** ,Head Researcher, Plant Protection Station Sabahia, Agriculture Research Center, for his supervision and encouragement with valuable comments and unique instructions and incredible spirit in fulfilling this work.

My profound thanks are due to **Emeritus Prof. Dr. Abdel-Fattah S.A. Saad**, Professor of Pesticides Chemistry and Toxicology, Plant Protection Department, Faculty of Agriculture, Saba Bacha, Alexandria University, for his support and encouragement during this research study.

I would like to express my deepest gratitude to **Prof Dr. Mohamed Refaat Rasmy,** Head Researcher, Plant Pathology Institute ,El-Sabaheia, Alexandria **,**for his supporting, encouragement with valuable comments on this dissertation..

My profound thanks are due to **Prof. Dr. Ahmed saleh Abo-shanab.**, Senior Researcher, Plant Protection Station Sabahia, Agriculture Research Center, for his encouragement with valuable comments and unique instructions and incredible spirit in fulfilling this work.

I am very grateful to **Prof. Dr. Khadega. S. Moursi.** Head Researcher, Plant Protection Station Sabahia, Agriculture Research Center, I would like to express my appreciation for his cordiality and support.

My profound thanks are due to **T. Stanes & Company Ltd., India**, for his supplying me with his valuable bio insecticides were kindly donated by Agronomy **safe gaara**

I am very grateful also to the Researcher, **Ahmed Sobhi Tag Barakat,** Assistant Researcher in Plant Protection Station, Sabahia, Agriculture Research Center, for his guidance, kind help, support, preparation of the thesis and active help throughout all phases of this work..

My profound thanks are due **Khaled Hassan Mohamed**, Agronomy, Plant Protection Station Sabahia, Agriculture Research Center, for his active help throughout of this work

My profound thanks are due to **Prof. Dr. Richard A. Humber** USDA-ARS Plant Protection Research Unit US Plant, Soil & Nutrition Laboratory for his supplying me with his valuable publications and cooperation in fulfilling this manuscript.

Deep appreciation is also expressed to my colleagues and stuff members in Plant Protection Department, Faculty of Agriculture, Saba Bacha, Alexandria University and Plant Protection Station Sabahia, Agriculture Research Center for their facilities and cooperation they offered during the course of this dissertation.

Last but not least, I am deeply grateful to my beloved family especially my mother for their understanding patience, for their inspiration and constant encouragement, without their sacrifice and patience, this thesis would never have been possible.

CHAPTER 1

INTRODUCTION

Several hundred mealybug species are well known and most plants are susceptible to one or more of these insects. Some species, like the citrus mealybug and obscure mealybug, exited on many different hosts throughout mild-winter areas. Mealybugs tend to congregate in large numbers, forming white, cottony masses on plants. High population slow plant growth and cause premature leaf or fruit drop and twig dieback. Honeydew production and black sooty mold are the primary damage caused by the most mealybugs. Also, high population can cause plant decline, and young plants may be killed.

Scale insects are common and damaging insect pests. They are easily overlooked because they are small and immobile Most of their lives do not resemble most other insect. Scales feed by sucking plant juices, and some may inject toxic saliva into plants. When numerous, scales weaken a plant and cause it to grow slowly. Leaves of infested plants turn yellow and foliage and fruit may become black from sooty mold or drop prematurely. Branches or other plant parts that remain heavily infested die, if they die quickly, the dead brownish leaves may remain on branches giving them a scorched appearance. The importance of infestation depends on the scale species, the plant species, cultivar, or variety, environmental factors and natural enemies.

Pesticides are substance applied to kill or repel pests or control damage. They can provide a quick but temporary reduction in pest populations. Some pests develop resistance to pesticides, so that spraying becomes less effective. The tolerant and resistant individuals are more likely to survive an application and produce descendents. Pesticides sometimes damage plants (cause phytotoxicty), especially if plants lack proper cultural care, environmental condition are extreme, or pesticides are used carelessly.

Pesticides are currently the principal tool for pest control and will likely continue to be used until more biologically based management systems can be developed and to meet this demand, pesticides suppliers have begun to commercialize biopesticides as an alternative for chemical ones.

Biopesticides are naturally organisms or by-products that can be used to control pests. The entomopathogenic fungi can be used as biopesticides since they cause infection to their respective hosts. The entomopathogenic fungi can attack a wide range of both immature and adult insects. They also available now commercially as biopesticides because they can be mass-produced by a fermentation process and formulated to enable the fungi to withstand ultraviolet light and temperature and humidity conditions encountered in the field.

The present work was designed to coincide the following requirements:

1- Survey the naturally and originally exiting entomopathogenic fungi related to the scale insects and mealybug infesting guava and orange trees at different orchards in different governorates in Egypt.

2- Isolation and identification of these entomopathogens.
3- Bioassay of the fungus *Verticillium lecanii* against the mealybug *Icerya seychellarum seychellarum* and the green shield scale insect *Pulivnaria psidii*.
4- Evaluation of the biological activity of certain commercial entomopathogenic fungi and a botanical insecticide formulations against certain scale insects and the mealybug *Icerya seychellarum* attacking guava and orange trees, and
5- study the mode of action of the entomopathogenic fungus *Beauveria bassiana* through scanning and transmission electron microscopy studies.

CHAPTER 2

REVIEW OF LITERATURE

2. 1. Scale insects and mealybugs as important pests infesting fruit trees in Egypt.

Scale insects were present in different parts of the world and they fall within 23 families. Out of them 12 families are found in Egypt and the most important families were: the armored scale insects (Diaspididae), the mealybugs (Morgarodidae and Pseudococcidae) and the soft scales (Coccidae). All important families contain dangerous species that attack different important economic crops in Egypt (**Abd-Rabou, 2003**)

Hamon and Williams (1984) reported that most of these polyphagous eurymerous scale insects species are feed on various parts of the host plant; leaves, stem bark, crowns and roots. The main injury caused by these insects is due to their ingestion of plant sap. The damage is manifested in reduction of plant vigor. Severely infected plants grow poorly; prematurely leaves may drop and suffer dieback of twigs and branches.

Ezzat and Nada (1986) reported that scale insects are notorious pests on perennial plants as well as fruit and nut trees. These pests belong to super family Coccoidae that contained twelve families; three of them belong to genus *Icerya*: *I. aegyptiaca* (Douglas), *I. Purchasi* Maskell and *I. seychellarum* (Westwood).

Kosztarab (1990) found that the damage caused by scale insects is not primarily due to plant-sap ingestion itself but more often to the toxic substances in the saliva which are injected into the plant tissue during the feeding process. Enzymatic activity then causes a reaction by the host plant

that is manifested in different ways (a) on leaves chlorosis (normally appears as a general or spottily yellowing), (b) on fruits reddish discoloration encircles the insects while underneath the scale the surface remains green, (c) shoot and leaf petiol deformation, (d) twig and branches deformations usually as depressions on the barks, (e) shallow often inconspicuous open-top pit galls or blister-like galls are produced, (f) rarely pouch-like galls are produced on host twigs and leaves, (g) a witches-broom type of deformation caused, (h) necrosis of cambial tissues and stopping of the sap transportation in the phloem is caused in cases of heavy infestation, (i) abortion of fruits due to feeding on the fruit pedicel is often observed, (j)yellowish-brown discoloration as well as depression and cracking of the fruit skin has been noted on orange fruits, and (k) distortion of young fruits like olives is often indicated.

Ghabbour and Mohammad (1996) stated that the family Diaspididae (the armored scales) represents the largest family of the super family belonging to which includes major pests in Egypt. 72 species were listed of this family in Egypt. The second largest family is Pseudococcidae that have 47 species of the mealybug belong to 28 genera.

Mohammad (1998) reported that the family Margarodidae is represented by six species of the mealybug and the family Coccidae is commonly referred to as the soft scales represented the third largest family of scale insects.

2.1.1. Scale insects

2.1.1.1. The Armored scale insect *Hemiberlesia latania* (Signort)

Swailem (1972) reported that the armored scale insects have a wide range of host plants. They attack many species of economic plants as mango, date palm, guava, peach, apple, olive and ornamental plants and the author noted that *Hemiberlesia latania* (Signort) attacking guava trees.

Miller and Kosztarab (1979) reported that the armored scale insects are notorious plant pests particularly on perennials. They are especially serious pests on fruit and nut trees and 17 armored scale insects species attacking citrus trees were recorded (**Nada, 1990**). Also, *H. latania* (Signort) was found to attack mango trees (**Elwan, 1990**).

Rosen (1990) reported that the armored scale insects, constituting the large family Diaspididae (Homoptera: Coccoidea), are highly evolved specialized as plant parasites and they have a fascinating life history being legless wingless and eyeless. Sap feeding females are covered by waxy shields incorporating the exuviae, while motile males do not feed as adults.

Miller and Davidson (1990) reported that the main injury caused by the armored insects is the ingestion of plant sap and their damage is manifested in reducing the number of healthy plants. Severely infested plants grow poorly and prematurely leaves may drop and suffer dieback of twigs and branches. Diaspididae is the largest and most specialized of the dozen or so currently recognized families which compose the superfamily Coccoidea. A recent world catalog lists 338 valid genera and approximately 1700 species of the armored scale insects.

Gomaa *et al.* (1991) surveyed the insects and mites associated with fig trees in irrigated farm system in the Egyptian Western desert. They found thirty-three insect and mite species at Burg El-Arab area (50 km west of Alexandria). They stated that eighteen species are common pests, while they recorded *Ceroplasets rusci* L. and *Parasaissetia nigra* (Neither) from family Coccidae, *Lepidosaphes minima* (Neither), *Quanderspidiatus pyri* (Licht.) and *H. lataniae* Hall from family Diaspididae and considered the fig scale *Asterolecanium pustulans* (Cockerell) as a key pest of the fig branches in this area. They showed that the population fluctuation of the densities of *A. pustulans* during 1988-1989 recorded three periods of abundance, the first period took place from April to July. During this period, the population increased and reached its peak of 21.1% (of the total count/year) during May. The second period lasts from July to October with a beak of 11.6% of the total count/year during August. The third period occurs during November when the peak reach 23.7% (of the total count) and stated that the fig scale *A. pustulans* has two overlapping generations of fig trees under irrigation system in the Egyptian Western Desert. The first one lasts from January till May and the second from July till November.

Moursi and Gomaa (1991) listed the scale insects and mealy-bugs infested the wild and cultivated plants in the Egyptian Western-Desert. A total of twenty-eight

species belonging to twenty-three genera and six families were found on the observed plants in natural and agroecosystems (rain-fed and irrigated farms). They recorded *Asterolecanium pustulans* (Cock), *Caroplastus rusci* Schn, *Parasaissetia nigra* (Neither) and *Lepidosaphes ficus* infested branches of *Ficus carica* and *Hemiberlesia lataniae.* The recorded insects infested leaves twigs fruits of the same host plant but they recorded *L. minima* Newst. and *Quadraspidiatus pyri* (Licht.) infested the leaves of that plant (fig trees) and recorded the insect *Parlatoria oleae* (Clovee) infested the twigs of *Prunus amygdalus* (almond).

Blank *et al*. (1994) stated that the diaspidid insect *Hemiberlesia lataniae* infested up to 34% of the fruits of avocados in New Zealand during 1991-92. The high proportion of the immature scales found on the fruit in late November indicated that scale invasion coincided with pollination. Two bee-safe insecticides (alone and in combination) were tested as sprays against the insect pest at the time of pollination in 1992. Buprofezin and fluvalinate at 16.7 and 8 g a.i./100 liters, respectively exercised up to 74% control.

Moursi (1996) in a project of IPM on fruit trees (olive, fig and almond) in the coastal area of Egyptian Western desert stated that the fig trees in the inspected farms under dry and irrigation system proved to harbor thirty-six species of insects and mites especially, *Ceroplastes rusci* L.; *Parasaissetia nigra* (Neiten); *Lepidosaphes ficus*; *L. minima* News; *Quaderspidiotus pyri* (Licht); *Hemiberlesia lataniae* Hall and *Asterolecanium pustulans* (Cockerell). She recorded the diaspided insect *Nilotaspis halli* on almond leaves and branches in dry farm system and proved that this scale insect represented a high percent of infestation in these farms.

Moustafa (1998) reported three peaks of *H. latania* on fig trees in January, April and November. He recorded three overlapping generations per year. The first took about three months, the second took seven months and the third took two months.

Blank *et al.* (2000) investigated the spatial dispersion of the armored scale insects. The abundance of the greedy scale *Hemiberlesia rapa*x (Comstock) and Latania scale *Hemilerlesia lataniae* (Signret) were investigated on Kiwi fruit leaves. A universal description of dispersion was determined using Taylor's power law which encompassed a wide range of different orchards blocks. Block sizes, sampling times, scale control practices, regions and seasons scale density significantly altered dispersion especially at the high densities found on unsprayed kiwifruit, trees Most commercially managed kiwifruit blocks had low densities of < 0.5 scale / leaf and had a slightly aggregated scale dispersion. The application of Wilson and Room's binomial model which incorporates a clumping pattern as a function of density gave a significant relationship between the proportion of infested leaves and scale density. The optimal leaf sample sizes were estimated for predetermined levels of sampling reliability where population estimates require a high degree of precision and enumerative sampling methods were used 2500 leaves should be sampled when scale densities are near the current spray threshold of 4% infested leaves and 500 leaves at 20% infested leaves for management-decision sampling where a lower level of precision was acceptable. Enumerative sampling would require 400 leaves to be sampled at 4%; or 85 leaves at 20% infested leaves. With binomial sampling and to achieve an equivalent level of precision, an increased sample size of 6-11% was required.

Charles and Henderson (2002) prepared a catalogue of the exotic armored scale insects in New Zealand. The catalogue was developed from studies of accurate specimens and literature. Twenty-eight species of exotic Diaspididae have established in New Zeeland, *Diaspidiotus perniciosus*, *Hemiberlesia lataniae* and *Hemiberlesia rapax* were among them. They added that *Hemiberlesia latania* (Signoret) is a polyphagus insect and was first recorded in New Zeeland at 1979 by **Morales (1988)** and distributed in North Island. In New Zeeland, its life cycle is uniparental with two overlapping generations/ year. The latania scale was regularly intercepted by quarantine officials on important plants from at least 1951. It has now established widely through the North Island and was found on a wide variety of fruit crops on wood leaves and fruits. It was likely to be an increasing pest of fruit crops such as Kiwifruit avocado and mandarins. It was first recorded on native plants in unmodified forests in 1998.

Verma and Dinabandhoo (2005) reported that the scale insects are very dangerous pests of fruit trees and they suck the sap from the above ground plant parts thereby causing the injury. The survey work brought to light eleven species of the scale insects infesting different fruit trees in nine districts of Himachal, Pradesh, India. The infestations of the following diaspidids viz. *Aonidiella aurantii* was recorded on citrus spp. (hill lemon, rough lemon, sweet lime and sweet orange) and grapes; *Aonidiella orientalis* on guava, mango and olive; *Aulacaspis tubercularis*, *Chrysomphalus dictyospermi*, *Hemiberlesia lataniae* and *Octaspidiotus tripurensis* on mango; *Chlidaspis asiatica* on apple and plum; *Morganella longispina* on olive and walnut; *Parlatoria oleae* on apple, apricot, pear, plum and sweet cherry; *Pseudaulacaspis manni* on walnut; and *Quadraspidiotus perniciosus* [Diaspidiotus perniciosus] (Comstock) on apple, peach, pear and plum. Out of the above- mentioned diaspidids *C. asiatica* was reported for the first time from India infesting apple and plum Also, *Aulacaspis tubercularis, C. dictyospermi, H. lataniae, O. tripurensis, M. longispina* and *Pseudaulacaspis manni* were reported for the first time from Himachal, Pradesh. The distribution host fruit plants and identification key to all these species are discussed.

2.1.1.2. The Soft scale insects *Ceroplastes floridensi* (Comstock) and *Pulvinaria psidii* (Maskell)

El – Minshawy *et al*. (1974) stated that *Pulvinaria psidii* Maskell is the most serious soft scale insect infesting guava trees in Alexandria.

El-Minshawy and Moursi (1976) described the biology and injuriousness symptoms of *Chloropulvinaria psidii* (Mask.) (*Pulvinaria psidii*), *C. floccifera* (Westw.), (*P. floccifera*) and *Parthenolecanium persicae* (F.) (as insect-pests of guava in Egypt) through laboratory and field observations. The egg stage of *C. psidii* lasted 11-28 days and although crawlers failed to settle on pumpkin fruits in the laboratory, second- and third-instar females succeeded. The number of eggs laid averaged 200.4/female and the life-cycle occupied 180-210 days. All stages of *C. floccifera* settled on pumpkin in the laboratory. The number of eggs laid averaged 857/female and the duration of the egg stage varied from 5 days at 27 º C to 23.3 days at 17-20 º C. At 22.5ºC, the duration of the first, second and third larval stages averaged 11.3, 9.7 and 15.7 days, respectively. The life cycle lasted for 35.7 days at 22.5-28º C and 43 days at a constant temperature of 27º C. *P. persicae* was a viviparous adult female giving rise to an average of 475.4 crawlers, each at a rate of 11.8 day. The 3 nymphal stages occupied 29.5, 43.4 and 59 days, respectively and the life cycle occupying 134.4 days.

All the tested three species reproduced parthenogenetically and no males being found in the investigations.

Swailem *et al.* (1976) carried out a field study in Egypt on the fluctuations of population density of *Ceroplastes floridensis* Comst. in orange groves in the governorates of Alexandria, Beheira, Gharbeia, Menufeia, Qalyubeia, Sharkeia and Giza. Populations of the scale insects were considerably larger in Alexandria and Beheira than in Sharkeia and Gharbeia, while they were very small in the other three (more southern) governorates. Population peaks were observed during October-December, March- May and August-September. Populations increased during late summer and autumn and they were smallest during winter. Although, infestations occurred on both leaf surfaces, they were heavier on the upper surface. All the scale insects observed were either female nymphs or adult females.

Hafez *et al.* (1978) mentioned that the genus *Ceroplastes* is widely distributed through out the world and considered to be among the most injurious pests of fruit trees and ornamental plants.

Schneider *et al.* (1987) studied that the tactic behavior and spatial distribution of *Ceroplastes floridensis* on citrus in 3 localities in Israel. The crawlers had a strong attraction to light but a weak response to gravity and they were therefore negatively geotactic. The young females were mobile before oviposition moving from leaves to branches for distinct periods during spring, summer and autumn. Most of the movement of the older nymphs and adults coincided with the annual leaf-fall of citrus. Treatment of the trees with Ethrel® [ethephon], a plant growth regulator which induces ethylene release in leaf tissue caused an increase in scale-insect movement on excised citrus leaves. The relationship between inter-tree variance and mean population density / tree was used to determine the sample size required to obtain a precision level of 0.1. The analysis of changes in distribution from one development stage to the next within each generation indicated that mortality was independent of density..

Malumphy (1988) recognized the economic importance and life cycle of *Pulvinaria* spp. in Britain where they attack mainly forest fruit and nut trees, woody ornamentals and indoor plants. The most common species in Britain is *P. regalis* which was first recorded in the country in 1964 and has since became widespread on a number of forest trees in Southern Britain. The most economically important species are *P. vitis* on vines and *P. ribesiae* on red and black currants and gooseberry.

Ben – Dov (1993) reported that the soft scale insects (Homoptera: Coccidae) occur in all zoogeographic regions of the world.

Peleg and Bar-Zakay (1995) reported that the significant changes have occurred in the economic importance of scale insect pests in Israeli citrus groves. *Aonidiella aurantii* was a destructive pest until the mid-1980s, due to its remarkable build-up of resistance to organophosphates and a disrupted biological balance. Since the mid-1980s, the pest has been under satisfactory control by the use of the insect growth regulator (IGR) pyriproxyfen (Tiger®) and an improved biological balance. *Ceroplastes floridensis* occasionally causes considerable damage. Improved biological balance helps to keep this pest below the economic threshold level, however under certain climatic conditions pest outbreaks occurred and required chemical control. *C.*