



Faculty of Science
Dep. Entomology

The feasibility of using modified atmospheres to control two museums insect pests, *Anthrenus verbasci* (Coleoptera: Dermestidae) and *Tinea pellionella* (Lepidoptera: Tineidae).

A Thesis

Submitted to the Faculty of Science, Ain Shams University for the award of Ph.D. degree of Science
(Entomology)

By

Nagwa Hassan Atiya Mabrouk El-Shafeay
(M.Sc. Entomology 2012)

Supervised by

Prof. Dr. Bahira Mahmoud El Sawaf
Professor of Entomology

Prof. Dr. Hoda Mohammed Abdel Fattah
Professor of Insect control

Prof. Dr. Ahmed Abdel Ghafar Abdou Darwish
Professor of Economic Insects

Prof.Dr. Sawsan Sayed Darwish
Professor of Biochemistry

Dr. Mohamed Ali Mahmoud Abdou
Lecturer of Entomology

Faculty of Science - Ain Shams University

2017

Board of Supervision

Prof. Dr. Bahira Mahmoud El Sawaf

Professor of Entomology - Entomology Department
Faculty of Science - Ain Shams University

Prof. Dr. Hoda Mohammed Abdel Fattah

Professor of Insect control-Entomology Department
Faculty of Science - Ain Shams University

Prof. Dr. Ahmed Abdel Ghafar Abdou Darwish

Professor of Economic Insects -Stored product
Department -Faculty of Agriculture –Benha University

Prof.Dr. Sawsan Sayed Darwish

Professor of Biochemistry, Conservation department
Faculty of Archaeology, Cairo University

Dr. Mohamed Ali Mahmoud Abdou

Lecturer of Entomology, Faculty of Science,
Ain Shams University

Biography

Name: Nagwa Hassan Atiya Mabrouk El-Shafeay

Degree Awarded: M.Sc. (Entomology), 2012

Department: Entomology

Faculty: Science

University: Ain Shams

Date of Graduation: 2005

Occupation: Insect Control Specialist / Pest Control
Laboratory/ Center of Researches & Conservation of
Antiquities.

Date of Appointment: 12/7/2006

Date of Registration for PhD. Award: 9/12/2013

ACKNOWLEDGMENTS

First of all, my thankfulness is to **ALLAH** for giving me the power and support to perform this work.

I would like to gratefully acknowledge my major supervisor **Prof. Dr. Bahira Mahmoud El Sawaf**, Professor of Insect Physiology, Ain Shams University who assigned the work, supervised it, and always pushed me further to try new things and to introduce me to worlds I might not have explored on my own. Also for her valuable advice during the performance of this work, supporting me through the hard times and helping me overcome difficulties.

I am greatly indebted to **Prof. Dr. Hoda Mohammad Abdel Fattah**, Professor of Insect Control, Ain Shams University for her supervision, kind encouragement and valuable advice. , being a pillar of support and was patient enough to teach me aspects I was largely ignorant of.

Prof. Dr. Hoda, you have been so much more than a supervisor, words do not do justice to the influence you have had on my life, during the most difficult times I have ever experienced.

Of course, I wish to thank **Prof. Dr. Ahmed Abdel Ghafar Abdou Darwish** , Professor of Economic Insect Stored product Department, Faculty of Agriculture, Benha University;

who was always encouraging me, advising me, and for helping, assistance and continual advices during this work.

I am greatly thankful to ***Prof.Dr. Sawsan Sayed Darwish*** Professor of Biochemistry, Conservation department, Faculty of Archaeology, Cairo University, for providing great help and guidance for our work.

I would like to thank ***Dr. Mohamed Ali Mahmoud Abdou*** Lecturer of Entomology, Faculty of Science, Ain Shams University, Entomology department for providing great help and guidance for our work.

I would like to thank ***Prof.Dr. Hala Kassem*** professor of medical entomology, Institute of Environmental Sciences and Research, Ain Shams University, for her keen assistance and reviewing the statistical analysis of the data.

I am thankful to ***Prof. Dr. Hassan Hamadna AllahFadl***, Professor of Insect Taxonomy, Ain Shams University for providing identification of specimens in our work.

Special thanks to ***Prof. Dr. Ragaa El Mohammady*** professor of Entomology and head of Entomology Department, Faculty of Science, Ain Shams University.

Thanks are due to the staff members of Center of Research and Conservation of Antiquities; Coptic Museum, Supreme Council of Antiquities.

My grateful acknowledgment is due to the staff members of Entomology Department, Faculty of Science, Ain Shams University; the staff members of Plant protection department, Faculty of Agriculture, Moshtohor, Benha University, for their kind help.

I'm grateful to all the great friends I have, I hope they know how much I appreciate them.

And of course, very special thanks to my wonderful family for all their love and support. Without you, so many things would not have been possible.

Dedication

To the spirit of my parents, love and appreciation for their role in my life. They were always the light which illuminates the way for me and encouraged me, supported me through the hard times, helped me relax and enjoy life and made my life a pleasure.

God have mercy and forgive them and give them the Supreme
Paradise.

LIST OF CONTENTS

Title	Page No.
I- INTRODUCTION	1
II- LITERATURE REVIEW	5
1. Insect pests infesting museum's collections.	5
2. Efficacy of controlled (modified) atmospheres against insects.	14
3. The effect of insect infestation and low oxygen atmospheres on artifacts and museum textile.	27
III-MATERIALS AND METHODS	31
1. Toxicological studies.	31
1.1. Tested insects.	31
1.1.1. Origin of insects.	31
1.1.2. Rearing technique of stock cultures.	32
1.2. The susceptibility of insects to argon and nitrogen gases.	33
1.2.1. Exposure procedure.	33
1.2.2. Gases used.	35
1.2.3. Determination of gases concentrations.	36
1.2.4. Preparation of insects for gas treatment.	36
1.3. Bioassay tests.	37
1.4. Statistical analysis of the data.	38

2. Effect of low oxygen atmosphere containing argon or nitrogen gas and insect infestation on thermally aged woolen samples.	39
2.1. Thermal aging of wool samples.	39
2.2. Treatment of aged woolen samples with argon or nitrogen gas after insect infestation.	40
2.3. Analysis of woolen samples properties.	40
2.3.1. Mechanical properties (tensile strength).	40
3. Examination of the effect of argon or nitrogen gas on both insects and aged textile with Scanning Electron Microscope (SEM).	43
3.1. Preparation of insects for scanning.	43
3.2. Preparation of textile for scanning.	44
4. Semi-field applicable method.	44
IV- RESULTS	46
1. Insect control studies.	46
1.1. The sensitivity of insects to gases.	46
1.2. Sensitivity of <i>Anthrenus verbasci</i> to modified atmosphere containing various concentrations of argon.	46
1.3. Sensitivity of <i>Tinea pellionella</i> to modified atmosphere containing various concentrations of argon.	51
1.4. Sensitivity of <i>Anthrenus verbasci</i> to modified atmosphere of high nitrogen content.	55
1.5. Sensitivity of <i>Tinea pellionella</i> to modified atmosphere of high nitrogen content.	58

2. Effect of insect infestation and argon or nitrogen gas on thermally aged textiles.	62
2.1. Effect of argon gas on the tensile strength of the thermally aged textile infested with larvae of <i>A. verbasci</i> and <i>T. pellionella</i> .	62
2.2. Effect of nitrogen gas on the tensile strength of the thermally aged textile infested with <i>A. verbasci</i> and <i>T. pellionella</i> .	64
2.3. Effect of argon and nitrogen gases on the chemical properties of the thermally aged textile infested with <i>A. verbasci</i> and <i>T. pellionella</i> .	67
3. Effect of modified atmosphere containing argon or nitrogen gas on <i>A. verbasci</i> and <i>T. pellionella</i> and morphology of thermally aged textiles.	74
3.1. The external morphology of sensilla on the antenna of <i>A. verbasci</i> and the larval case of <i>T. pellionella</i> .	74
3.2. Effect of argon or nitrogen gas on antennae and their sensilla and larval case opening.	75
3.3. The external morphology of thermally aged textiles.	82
4. Semi-field applicable method with 99.9% argon for the control of <i>Anthrenus verbasci</i> and <i>Tinea pellionella</i> on textiles.	90
V- DISCUSSION	103
VI- SUMMARY	116
VII- REFERENCES	127
ARABIC SUMMARY	