

**Deanship of Graduate Studies
Al-Quds University**

**Ecological Investigations on the Terrestrial Biodiversity
in the Northern Part of the West Bank (Jenin Area)**

Amjad Ibraheem Saied Abu Jalboush

M.Sc. Thesis

Jerusalem –Palestine

1429 Hijri / 2008

**Ecological Investigations on the Terrestrial Biodiversity
in the Northern Part of the West Bank (Jenin Area)**

Prepared By:
Amjad Ibraheem Saied Abu Jalboush

B.Sc in Agriculture (Plant Production and Protection)
An-Najah National University –Palestine

Supervisor: Dr. Azzam Saleh

A thesis submitted in partial fulfillment of requirement of
the degree of Master of Sustainable Rural Development /
Agricultural Extension / Deanship of Graduate Studies/
Al-Quds University

1429 Hijri /2008



Thesis Approval

**Ecological Investigations on the Terrestrial Biodiversity in the Northern
Part of the West Bank (Jenin Area)**

Prepared By: Amjad Ibraheem Saied Abu Jalboush
Registration Number: 20411401

Supervisor: Dr. Azzam Saleh

Master thesis submitted and accepted, 12/1/2008.
The names and signatures of the examining committee members are as
follows

Head of committee : Dr. Azzam Saleh

Signature

Internal examiner: Dr. Khaled Salem Sawalha

Signature

External examiner: Dr. Ahmad Shwaika

Signature

Jerusalem –Palestine

1429 Hijri / 2008

Dedication

To My

Great Parents
Beloved Wife
Nice Children, Duha and Ahmad
Brothers and Sisters

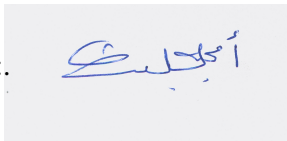
To all of them this small work is dedicated

Amjad Ibraheem Saied Abu Jalboush
12/1/2008

Declaration

I certify that this thesis submitted for the degree of Master is the result of my own research, except where otherwise acknowledged, and that this thesis (or any part of the same) has not been submitted for a higher degree to any other university or institution.

Signed:.

A rectangular box containing a handwritten signature in blue ink. The signature is written in Arabic script and appears to be 'Amjad Ibraheem Saied Abu Jalboush'.

Amjad Ibraheem Saied Abu Jalboush

Date: 12/1/2008

Acknowledgements

First of all my deepest thanks and gratitude is for my God for supporting me with power, Patience, and determination throughout my study period.

My sincere thanks for my supervisor, Dr. Azzam Saleh, who has saved no effort or time in providing me with his valuable guidance and advices throughout the research.

And I would like to thank Professor Dr. Mohamad Saleem Ali-Ishtayeh for his efforts and assistance during my research. I would also like to thank BERC for their assistance.

Special dept of gratitude is due to the German Federal Ministry of Scientific Research and Education (BMBF) for their generous financial support during the research, which is provided in the framework of the research project “Modeling the Impact of Global Climate Change on Terrestrial Biodiversity in the Jordan River Basin: Testing planning scenarios and climate change scenarios.”(GLOWA phase II).

Special thanks to the Palestinian ministry of agriculture, especially the former minister of agriculture Dr. Waleed Abed Raboh, Deputy Minister Dr. Azzam Tubieleh, D.G of Extension and Rural Development Mr. Abdullah Lihluh. Project Manager Mr. Younis Subieh and the UNDP for their assistance in the scholarship through the “Conservation and Sustainable Use of Dry Land Agro biodiversity in the Palestinian Authority”

Also I highly appreciate the assistance of my brother’s son Ibraheem Abu Jalboush during field visits and sample collection.

I would like also to thank Al-Quds University, Sustainable Rural Development Program, Dr Ziyad Qannam the director of the program and other staff for their assistance

Abstract

This study was conducted to investigate the terrestrial biodiversity in the northern part of the West Bank (Jenin Area), and was carried out from June 2006 to April 2007. This study was conducted in Mirkeh area as a representative of the northern part of the West Bank, ecological characterization of the area was made including the identification of the key climatic and ecological features, dominant species of plants and animals present, various rare and threatened plants and animal species present, key different species of small animals present. Pitfall trapping used to study the impacts of some environmental factors and grazing on arthropods diversity, temporal (seasonal) difference in the distribution of the arthropods.

Three 250-square meter plots were selected at each site of different land use management patterns (Protected natural grass land, and grazing grass land) to assess arthropods diversity. Pitfall trapping method was used for collecting arthropods. Four pitfall traps were placed in each plot. Pitfall Traps were made of 500 ml plastic containers as inner container and a 2-liter cola bottles as outer containers, with mono ethylene glycol as preservative. Arthropods were sampled once in the middle (7-21) of: July 2006, November 2006, January 2007, and April 2007 for summer, autumn, winter, and spring seasons respectively. At each sampling occasion, the pitfall traps were opened for two consecutive weeks (day and night). After one week the containers were removed and replaced by fresh containers.

Arthropod data were analyzed using SPSS. Chi square was used to find out if there were significant differences between land use treatments, while ANOVA was made to know if there were significant differences in the seasonal abundance of arthropods.

This study showed that the area have diverse location, topography, climatic conditions so this had lead to the richness and variation of vegetation cover which in turn establish the diverse habitats for animals. So many plant species are present in this area belonging to many plant families of which 34 different plant families have plants with relative importance, of these families; Anacardiaceae, Compositae, Cruciferae, Cucurbitaceae, Gramineae, Labiatae, Leguminosae, Liliaceae, Papilionaceae and Rosaceae. While 25 bird families comprised the most abundant birds in the area, of these families; Accipitridae, Alaudidae, Columbiidae, Corvadae, Fringillidadae, Passeridae, Phasianidae, Strigiadae, Sylviidae, and Turdidae. Within the area many wild animals were found like; hedgehodge, wild hare, mountain gazelle, hyrax, red fox, Egyptian mongoose, and many reptiles like; turtles, agma, snakes and lizards.

Many species of plants and animals present are considered threatened or endangered, threatened or rare plants are belonging to 14 plant families, while threatened and rare birds belonging to seven bird families, several animals considered threatened like; wild hare, mountain gazelle.

Thy study found that different invertebrates inhabit the site whether in vegetation or soil microhabitats, these arthropods play different roles in the ecosystem, and their population size is a matter of change due to environmental factors and seasonality, Beetles and ants are the major components of insects present in the site around the year, while scorpions, centipedes and millipedes in addition to beetles and ants are components in the site during

summer and autumn seasons. Many other canopy arthropods were found during spring and summer like Butterfly's, grasshoppers, dragon, fly's, Wasps, bumble bees, bugs, and aphids.

The study showed a high population level of average total arthropods collected in autumn (633 in protected grass land and 344 in grazing grass land), while the average number of arthropods decreases in winter (133 in protected grass land and 116 in grazing grass land). Average number of total insects has the same trend as the average number of total arthropods with a high population level of average total insects collected in autumn (579 in protected grassland and 254 in grazing grassland), while the average number decreased in winter (72 in protected grassland and 73 in grazing grassland).

Average number of spiders collected showed an increase in numbers in winter and spring (25 and 30 in protected grass and, 12 and 12 in grazing grass land respectively)

Results of Pearson Chi-square showed no significant differences between total arthropods collected per catch from the two treatments (Chi-Square=24, Sig. =0.404), and arthropod divisions showed the same trend which means that there were no significant effect of grazing management on arthropod diversity in the area.

One way analysis of variance for collected arthropods showed that there were highly significant difference between seasons in the total arthropods collected per catch (sig. =0.000) with autumn as the highest in total arthropods collected per catch (mean=488) decreasing in winter (mean=124), starts to increase in spring (mean=130), summer (mean=246) to reach its peak on autumn. Total insects per catch have the same trend of seasonality (sig. =0.000). autumn with peak number of total insects collected per catch (mean=416), decreasing to its minimum in winter (mean=72), starting to increase in spring (mean=79) and summer (mean=179), Beetles collected per catch have a high significant seasonality (sig. =0.000) with autumn as the maximum population of beetles (mean=251) starting to decrease in winter (mean=40), spring (mean=37) to reach its minimum in summer (mean=14). Non-insect arthropods (Spiders, Scorpions, Millipedes, and Woodlice) have a variation in their population along the season (sig=0.022) with peak number of collected Non-insect arthropods in autumn (mean=61) decreasing in winter (mean=33), reaches its minimum in spring (mean=30) and starts to increase in summer (mean=48), while on the other hand, spiders on the contrary of all other arthropods collected have no significant differences in their populations during the different seasons (sig. =0.142).

In order to study the status of biodiversity in the area many detailed studies may be carried out, the composition and abundance of plant and animals of the area may be studied, the impact of different land use practices on plants and animals and the ecosystem as a whole may be studied.

دراسة بيئية للتنوع الحيوي في منطقة شمال الضفة الغربية (منطقة جنين)

ملخص

تم اجراء هذه البحث لدراسة التنوع الحيوي في شمال الضفة الغربية (منطقة جنين) في الفترة ما بين شهر حزيران عام 2006 وحتى شهر نيسان عام 2007. تم اجراء هذا البحث في منطقة مركه الواقعة وسط محافظة جنين وكممثل لمنطقة شمال الضفة الغربية. تم عمل توصيف بيئي للمنطقة تضمن تعريف العوامل الجوية الرئيسية، الانواع الرئيسية للنباتات والحيوانات، اهم الانواع النباتية والحيوانية المهددة بالانقراض، واهم الحيوانات الصغيرة (مفصليات الارجل). كما تم استخدام المصائد الارضية لدراسة تاثير العوامل الجوية والرعي على التنوع الحيوي لمفصليات الارجل وكذلك تاثير الفصول عليها. تم اختيار ثلاث وحدات بمساحة 250 م² في كل موقع كمعاملة لاستعمالات الاراضي (اراضي عشبية محمية، واراضي عشبية رعوية) لدراسة التنوع الحيوي لمفصليات الارجل. وتم استخدام المصائد الارضية لجمع المفصليات، حيث تم وضع 4 مصائد في كل وحدة والتي تم عملها من عبوات بلاستيكية سعة 500 مل وتم تزويد المصائد باحادي ايثيلين الجلايكول كمادة حافظة. تم جمع المفصليات من 7-21 من شهر حزيران 2006، تشرين ثاني 2006، كانون ثاني 2007، وشهر نيسان 2007 كمثله لفصول: الصيف، الخريف، الشتاء، الربيع على التوالي وفي كل عملية جمع تم وضع المصائد لمدة اسبوعين متتاليين ليلا ونهارا وتم تغيير المصائد نهاية الاسبوع الأول. تم تحليل البيانات الخاصة بمفصليات الارجل باستخدام برنامج SPSS بحيث تم تحليل مربع كاي لدراسة تاثير الرعي على مفصليات الارجل، بينما تم عمل تحليل التباين الاحادي لدراسة تاثير الفصول على توزيعها.

أشارت الدراسة إلى أن موقع المنطقة، طبوغرافيتها، وظروفها الجوية ادت الى غنى وتنوع غطائها النباتي مما ادى الى ايجاد مواطن طبيعية للحيوانات المختلفة، وهذا ادى الى ايجاد عدة اجناس نباتية تنتمي الى الكثير من العائلات النباتية، منها 34 عائلة نباتية تحتوي على اجناس ذات اهمية نسبية ومن اهم العائلات النباتية: العائلة القلبية، المركبة، الصليبية، القثائية، النجيلية، الشفوية، البقولية، الزنبقية، الفراشية والوردية. بينما تمثل 25 عائلة معظم الطيور الموجودة في المنطقة ومن اهم هذه العائلات: عائلة الطيور الجارحة، العائلة القبرية، الحمامية، الغرابية، الشرشورية، العصافير النساجة، التدرجية، البوم الحقيقية، الهوازج والعائلة الشحرورية. كما يوجد في المنطقة مجموعة من الحيوانات البرية مثل النيص، القنفذ، الارنب البري، الغزال الجبلي، الثعلب والنمس، بالإضافة الى

الزواحف مثل: السلاحف، الحردون، الافاعي والسحالي. يوجد العديد من الاجناس النباتاتية المهددة بالانقراض، حيث يوجد عدة نباتات مهددة تنتمي الى 14 عائلة نباتية، بينما تنتمي الطيور المهددة الى 7 عائلات، بالاضافة الى وجود الارنب البري والغزال الجبلي والتي تعتبر مهدد بشكل كبير.

كما اشارت الدراسة الى وجود العديد من اللافقاريات التي تعيش في مختلف المواطن سواء النباتية او الارضية وتعتبر الخنافس والنمل اكثر المكونات الحشرية في الموقع على مدار العام، بينما العقارب، ميثيات الارجل، الفيات الارجل بالاضافة الى النمل والخنافس هي المكونات الرئيسية لمفصليات الارجل خلال اشهر الصيف والخريف، كما يوجد العديد من مفصليات الارجل التي تعيش على المجموع الخضري للنبات مثل الفراش، الجنادب، الرعاشات، النحل الطنان والمن.

ودلت نتائج مربع كاي الى عدم وجود فروقات معنوية ما بين مجموع المفصليات التي جمعت في كلا المعاملتين (مربع كاي 24 وقيمة الدلالة 0.404) وكذلك مجموعات المفصليات المختلفة مما يدل على عدم تأثير الرعي على تنوع مفصليات الارجل الموجودة في المنطقة.

بينما اشارت نتائج تحليل التباين الاحادي الى وجود فروق معنوية عالية للتغير الموسمي في اعداد مفصليات الارجل. (قيمة الدلالة 0.00) وكان الخريف اعلى معدل لمجموع مفصليات الارجل (معدل 488) وتتاقص العدد في الشتاء (معدل 124) وتبدء بالزيادة في الربيع (معدل 130) والصيف (معدل 246) لتصل الى اعلى مستوياتها في الخريف. كما ابدى مجموع الحشرات نفس المنحنى في التغير (قيمة الدلالة 0.00) بحيث كان اعلى عدد في الخريف (معدل 416)، ينقص العدد الى الحد الادنى في الشتاء (معدل 72)، ويبدأ بالزيادة في الربيع (معدل 79) والصيف (معدل 179)، كما كان لمجموع المفصليات الغير حشرية (عناكب، عقارب، ميثيات الارجل) تغير على مدى العام (قيمة الدلالة 0.022) بحيث كان اعلى معدل في الخريف (معدل 61)، يتناقص في الشتاء (معدل 33) ويصل الى ادنى مستوى في الربيع (معدل 30) ويبدأ بالزيادة في الصيف (معدل 48)، وعلى العكس لم يحدث اي تغير على اعداد العناكب بين الفصول (قيمة الدلالة 0.142).

من اجل دراسة وضع التنوع الحيوي في المنطقة نوصي بالقيام بدراسات تفصيلية، بحيث يمكن دراسة التركيب والكثرة للانواع النباتية والحيوانية المختلفة في المنطقة، وكذلك يمكن دراسة تاثير انماط استخدامات الاراضي على النباتات والحيوانات والنظام البيئي ككل.

Table of Contents

Item	page
Declaration.....	i
Acknowledgements.....	ii
Abstract.....	iii
Abstract in Arabic.....	v
Table of contents.....	vii
List of tables.....	ix
List of figures.....	x
List of appendixes.....	xiii
Definitions	xiv
Chapter one: Introduction.....	1
1.1 Background.....	1
1.2 Research problem.....	3
1.3 Research objective.....	4
1.4 Hypothesis.....	4
1.5 Outline of thesis.....	4
Chapter two: Literature review.....	5
2.1 Concepts of biodiversity.....	5
2.1.1 Genetic diversity.....	5
2.1.2 Species diversity.....	6
2.1.3 Ecosystem diversity.....	6
2.2 The importance of biodiversity.....	6
2.3 The loss of biodiversity.....	6
2.4 Agro-ecological zones of the West Bank.....	7
2.5 Ecological characterization of Jenin district.....	8
2.6 Agro-climatic regions of the Jenin district.....	10
2.7 Range lands of Palestine.....	10
2.8 Arthropods.....	11
2.9 Effect of grazing on biodiversity.....	11
Chapter three: Materials and methods.....	15
3.1 Selection of sampling area.....	15
3.2 Sampling site.....	15
3.3 Sampling of arthropods population.....	15

3.4	Setting up traps.....	17
3.5	Sample processing.....	18
3.6	Climatic data.....	18
3.7	Determination of Edaphic factors.....	19
3.8	Data analysis.....	20
Chapter four: Results and discussion.....		21
4.1	Main ecological features of Mirkeh sampling site as a representative of northern part of the West Bank.....	21
4.1.1	Key climatic and ecological features of Mirkeh sampling area.....	21
4.1.2	Key different species of plants and animals present in Mirkeh sampling area.....	24
4.1.2.1	Plant species present in Mirkeh sampling area.....	25
4.1.2.2	Animal species present in Mirkeh sampling area.....	31
4.1.2.2.1	Birds.....	31
4.1.2.2.2	Mammals.....	34
4.1.2.2.3	Reptiles.....	34
4.1.3	Various rare and threatened plant and animal species present in Mirkeh sampling area.....	34
4.1.4	Key different species of small animals present in these habitats in Mirkeh sampling site.....	34
4.2	Impacts of some environmental factors on arthropods diversity.....	39
4.3	Impact of grazing on arthropods diversity.....	41
4.4	Temporal (seasonal) difference in the distribution of the arthropods.....	41
4.5	Major options and priorities for action.....	45
Chapter five: Conclusions and recommendations.....		47
5.1	Conclusions.....	47
5.2	Recommendations.....	47
References.....		49
Appendixes.....		53

List of Tables

Table	Description	Page
Table 3.1	Physical and biotic characteristics of the study sites.....	16
Table 4.1	Different seasonal soil moisture percentages of Mirkeh sampling site...	24
Table 4.2	Different seasonal soil chemical properties of Mirkeh sampling site...	24
Table 4.3	Mean seasonal catch of different arthropods groups of Mirkeh sampling site.....	35

List of figures

Figure	Description	Page
Fig. 1.1	Districts of West Bank.....	2
Fig. 2.1	Mean annual rain fall for 20 years from different stations in the Jenin district.....	9
Fig. 2.2	Mean monthly maximum, minimum, & relative humidity at Beit Quad Weather Station for 42 years.....	9
Fig. 3.1	Mirkeh sampling area.....	16
Fig. 3.2	Sampling sites in Mirkeh sampling area.....	17
Fig. 3.3	Pitfall with cover.....	18
Fig. 3.4	Sample processing at BERC.....	19
Fig. 3.5	Soil samples collected.....	20
Fig. 4.1	Minimum and Maximum temperature recorded at Mirkeh sampling site.....	22
Fig. 4.2	Minimum, maximum relative humidity and rainfall recorded at Mirkeh sampling site.....	22
Fig. 4.3	Minimum, maximum and average temperature recorded at Az-Zababdeh station.....	23
Fig. 4.4	Minimum, maximum and average relative humidity and rainfall recorded at Az-Zababdeh Station.....	23
Fig.4.5	Carob Tree; <i>Ceratonia siliqua</i> of Caesalpinaceae family.....	26
Fig. 4.6	Storax Tree; <i>Styrax officinalis</i> (L) of Styracaceae family.....	26
Fig. 4.7	Palestinian Buckthorn; <i>Rhamanus palestinus</i> Boss of Rhamnaceae family.....	27
Fig. 4.8	Caper Shrub; <i>Capparis spinosa</i> (L) of Caparidaceae family.....	27
Fig. 4.9	Purple clover; <i>Trifolium purporeum</i> of Papilionaceae family.....	28
Fig. 4.10	Aegilops; <i>Aegilops buncialis</i> Vis of Gramineae family.....	29
Fig. 4.11	Medicinal Squill; <i>Urginea maritima</i> of Liliaceae family.....	29
Fig. 4.12	Anemone; <i>Anemone coronaria</i> (L) of Ranunculaceae family.....	30

Fig. 4.13	Hollyhock; <i>Alcea setosa</i> of Malvaceae family.....	30
Fig. 4.14	House Sparrow; <i>Passer domestica</i> of Passeridae family.....	32
Fig. 4.15	Kestrel; <i>Falco tinnunculus</i> of Falconidae family.....	32
Fig. 4.16	European Blackbird; <i>Turdus merula</i> of Turdidae family.....	33
Fig. 4.17	Robin; <i>Erithacus rubecula</i> of Turdidae family.....	33
Fig. 4.18	A: Turtle; <i>Testudo graeca</i> & B: Lizzard; <i>Acanthodactylus scutellatus</i>	34
Fig. 4.19	Silk Moth; <i>Saturnia pyri</i> of Saturniidae (Silk Moths) family.....	35
Fig. 4.20	Common Butterfly pollinating Almond Flowers.....	36
Fig. 4.21	Click Beetle; <i>Agrypnus notodonata</i> of Elateridae family.....	36
Fig.4.22	. <i>Sacred Scarb</i> of Sugar-Beetle (Scarabeidae) family	36
Fig. 4.23	Dung -Pusher Beetle; <i>Scarabacus sacer</i> of Ground Beetles (Carabidae) family.....	37
Fig. 4.24	Common Dust Beetle; <i>Opatrium sabulosum</i> of Ground Beetles (Carabidae) family.....	37
Fig. 4.25	<i>Pterostichus vulgaris</i> of Ground Beetles (Carabidae) family.....	37
Fig. 4.26	Bombardier Beetle; <i>Brchynus crepitans</i> of Ground Beetles (Carabidae) family.....	38
Fig. 4.27	<i>Hister fimentarius</i> of Prop Beetles (Histeridae) family.....	38
Fig. 4.28	Violet Ground Beetle; <i>Carabus violaceus</i> of Tiger Beetles (Cicindilidae) family	38
Fig. 4.29	Seasonal fluctuation of arthropod population in relation to environmental conditions.....	39
Fig. 4.30	Seasonal fluctuation of insect population in relation to Environmental conditions.....	40
Fig. 4.31	Seasonal fluctuation of spider population in relation to environmental conditions.....	40
Fig. 4.32	Variation in average number of total arthropods collected around the year.....	42
Fig. 4.33	Variation in average number of total insects collected around the year.....	42

Fig.4.34	Variation in average number of beetles collected around the year.	43
Fig. 4.35	Variation in average number of ants collected around the year.....	43
Fig. 4.36	Variation in average number of Non-insect arthropods collected around the year.....	44
Fig. 4.37	Variation in average number of spiders collected around the year.....	44

List of Appendixes

Appendix	Description	Page
Appendix 4.1	Different plant species of trees and shrubs present in Mirkeh sampling area.....	53
Appendix 4.2	Different herbaceous plant species present in Mirkeh sampling site.....	54
Appendix 4.3	Different key bird species present in Mirkeh sampling area.....	56
Appendix 4.4	Threatened and rare plants present in Mirkeh sampling area.....	58
Appendix 4.5	Threatened and rare birds present in Mirkeh sampling area.....	59
Appendix 4.6	Number of arthropods collected from the site during the four seasons.....	59
Appendix 4.7	Results of statistical analysis.....	61

Definitions

Abundance :	The total number of organisms in an area.(Ministry of Environment, lands and Parks 1998)
Arthropods:	Arthropods are invertebrates, that is, they have no backbone, and rely instead on an external covering called an exoskeleton. They get their name from their jointed (arthros) legs (podos). (Moldenke,(n.d), Heimler and Daniel 1987)
Biodiversity:	“The variability among living organisms from all sources including, <i>inter alia</i> , terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems”(IUCN,1992)
Consumers :	Animals in a food web that eat plants or other animals ;cannot make food (Heimler and Neal,1986)
Decomposer:	An organism that causes the decay or breakdown of dead plants and animals (Heimler and Neal.,1986)
Ecology:	The study of relation ships between organisms and their environments. (Heimler and Neal,1986)
Ecosystem	Systems composed of living organisms and the non-living environment with which they interact continuously.(California Agriculture ,1995)
Endangered Species	A species of plants or animals whose numbers are so small that it could easily become extinct. (Heimler and Neal,1986)
Genetic Diversity:	Genetic diversity is the variety present at the level of genes, which are the building blocks that determine how an organism will develop and what its traits and abilities will be.
Ecosystem Diversity	The term "ecosystem" represents all levels greater than species: associations, communities, ecosystems, and the like.
Extinct:	No longer existing (Heimler and Neal, 1986).
Habitat:	The place where species of plant or animal normally lives. (Heimler and Neal.C,1986)
Population:	The total number of any one species living in a community. (Heimler and Neal,1986)
Reptiles:	Vertebrate’s animals that are cold-blooded breathe air, and live mainly on land. (Heimler and Neal,1986)
Scavenger:	An animal that feeds on dead animals; a type of consumer. (Heimler and Neal,1986)
Species	A group of potentially interbreeding populations that are reproductively isolated from other such group .(California Agriculture ,1995)
Species Diversity:	Species are well known distinct units of diversity, and are relatively easy to identify by eye in the field
Threatened Species	Any species which is “likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.(California Agriculture ,1995)”

Chapter one

Introduction

1.1 Background

The area of Palestine is 27000 km², of which about 5856 km² in the West Bank and 365 km² in Gaza Strip. The West Bank is divided into four Agro-ecological zones: Simi–costal region, central highlands region, eastern slopes region, and the Jordan valley region.

Natural grazing areas of about 2180000 dunums are present which comprises about 35% of the total area of West Bank and Gaza strip, of which about 69% in the eastern slopes region. (Isaac, Wolf, and Quba'a 2005; Mohamad, 2005).

Range lands of Palestine have been greatly affected by Israeli colonies and urbanization. Only seven hundred thousand dunums of total grazing area are accessible to Palestinian livestock owners, the other area is currently inaccessible due to land confiscation for Israeli settlements, natural reserves, and military bases with water shortage as a serious problem.

The numbers of sheep and goat present in West Bank are 1103742 heads (PCBS, 2004/2005), Hebron and Jenin Districts have 40.87% of the total number, 26.67% (294382 heads) in Hebron and 14.2 % (157573 heads) in Jenin District. A small proportion of these ruminants were raised totally under shed conditions while most of livestock utilize rangeland to obtain part of its feed requirements (Mohamad, 2005).

Rangeland of the West Bank suffers from a severe deterioration, due to variation of rainfall, overgrazing, improper grazing time, uses of trees and shrubs as fuel source, and the cultivation of marginal land zone.

Human actions are major cause of biodiversity loss which transforms natural landscapes, and habitats in the negative direction. These activities include direct actions such as farming, forestry, and livestock raising, and activities as industrialization such as quarrying, stone cutting, charcoal making and other industries whose by-products may pollute, waste, the soil, air and water (Solbring, 1994).

Biodiversity in the West Bank suffers from several threats including (habitat alteration and loss, over harvesting and usage, species and disease introduction, pollution and climate change, Israeli occupation, overgrazing, agricultural practices, and hunting)

Jenin district is located in the northern part of the west bank (Fig.1 1). It is bounded by Nablus district from south, Tulkarm from south west, and the green line from other directions.

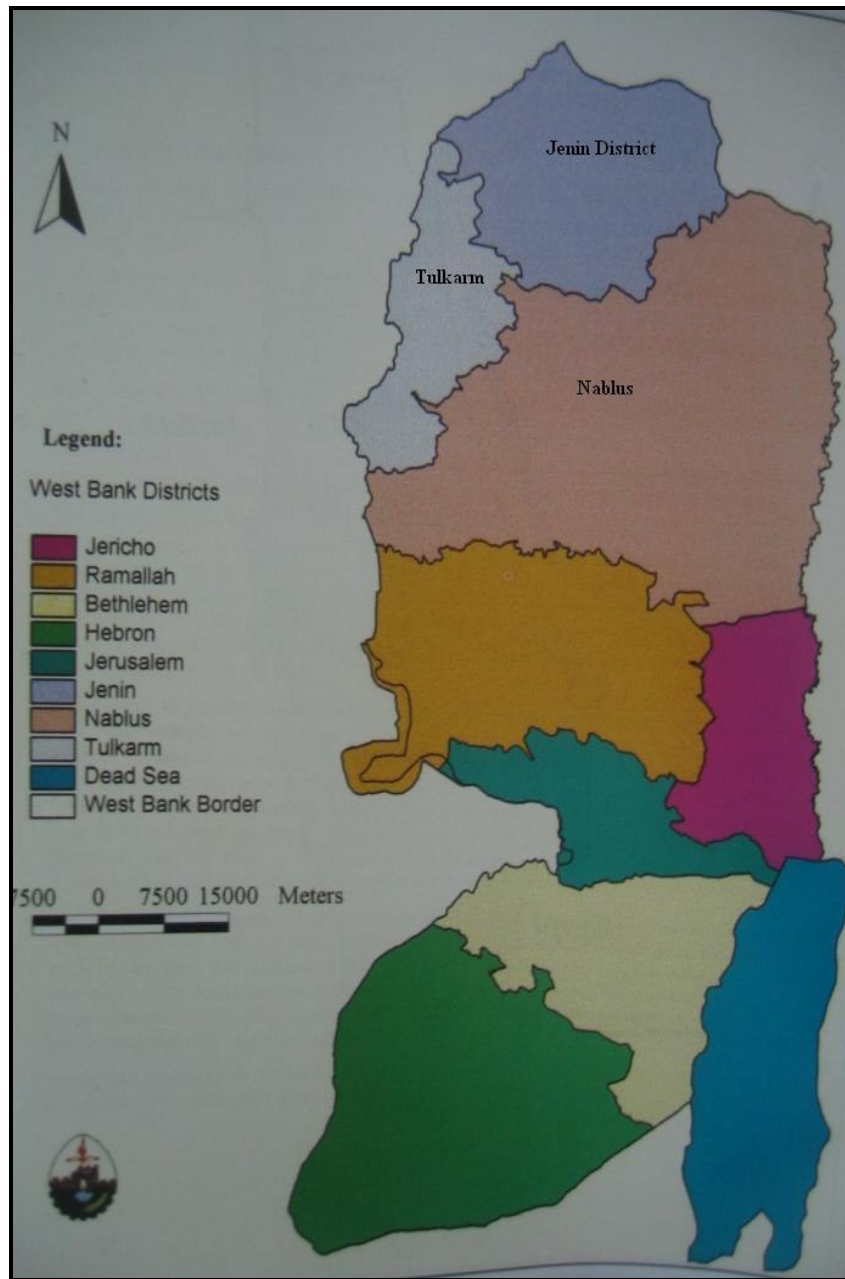


Fig 1.1: Districts of West Bank. (ARIJ, 1997)

The district is located between 90 and 750 meter above sea level, with an area of 592 km² and considered one of the best agricultural areas of Palestine because of the soil fertility and moderately high rainfall amount, and availability of water.

The topography of Jenin district can be divided into three areas, the eastern slopes, mountain crests, and western slopes.

The climate of Jenin district is governed by its position on the eastern Mediterranean and characterized by its moderate and rainy winter, hot and dry summer. The mean annual rain fall in Jenin district is 528 mm. The rainy season starts in the middle of October and

continues to the end of April, 80 % of annual rain fall occurs during November through February. Snow fall is rare in Jenin district. The average maximum temperature at Biet Quad weather station over the last 42 years was 27.1°C, while the average minimum temperature was 13.5 °C (ARIJ, 1996). The wind direction lies between southwest and north west, being more northerly during the summer, with an average daily wind speed of 9.2 Km/hour from June to August at Biet Quad weather station while in winter the mean daily wind speed from December to February is 7.7 Km /hour at Biet Quad weather station(ARIJ, 1996).

To perform this study a sampling site in the central part of Jenin district (Mirkeh village) were selected for many reasons like the presence and abundance of many plant and animal species, the availability of natural grazing area which can be protected, and the availability of some needed metrological data from nearby stations. Mirkeh sampling site is located south west of Jenin city with an area of 25 square kilometers; Longitude: 035°14'07 E, Latitude: 32°24'16 N, Elevation: 318 M above sea level; and annual rainfall 600 mm.

The district is characterized by its high variability and value of biodiversity .there is alack of studies and information about the status of biodiversity in the Jenin district, A study concerning vegetation were made through the project Sustainable Use of Dry land Agro biodiversity in Hebron and Jenin Districts, the study was concerned on wild relatives of some fruit trees and forage plants (MoA and UNDP, 2003).

No distinct studies have been made to study the biodiversity of the Jenin district, so within Mirkeh sampling area the status of biodiversity were studied including fauna and flora through many procedures, plants, mammals, reptiles and birds were studied by field visits around one year from May 2006-May 2007 using photograph documentation and different taxonomic and zoological references to identify different plant and animal species, while arthropods were studied using pitfall traps in tow treatments(Grazing and Protected) from June 2006-April 2007 within the sampling site.

1.2 Research problem

The Research Problem can be identified through the following questions:

1. What are the main ecological features (characters) of Mirkeh sampling area as a representative of northern part of the West Bank?
 - What are the key climatic and ecological features of Mirkeh sampling?
 - What are the key different species of plants and animals present in Mirkeh sampling area?
 - What are the various rare and threatened plant and animal species present in Mirkeh sampling area?
 - What is the key different species of small animals present in these habitats in Mirkeh sampling site?
2. What are the impacts of some environmental factors on arthropods diversity?
3. What is the impact of grazing on arthropods diversity?

4. Is there temporal (seasonal) difference in the distribution of the arthropods?
5. In light of the already existing planning and policies related to biodiversity protection in the Palestinian National Authority, what are the major options and priorities for action?

1.3 Research objectives

The present study has the following objectives:

1. To characterize the study area from an ecological point of view and identification of the various rare and threatened plant and animal species present.
2. To identify different species of small animals present.
3. To prepare permanent specimens of the different animal Taxa to be collected.
4. To monitor the temporal (seasonal) distribution of the key animal Taxa.
5. To collect information and propose recommendations regarding the planning and policies related to biodiversity protection in Palestinian National Authority.

1.4 Hypothesis

Biodiversity is expected to be affected by global climatic change which affects the distribution patterns of species through shifts in climatic zones, this effect may well contribute significantly to the global loss of biodiversity. Different species are expected to respond differently to climate change. Therefore, different land-use patterns, soil and environmental conditions, are expected to have a huge impact on the distributions of species. Moreover, this differential effect is expected to impact not only single species but also species assemblages and thus to transform ecological communities.

1.5 Outline of thesis

Within the following chapters of the thesis, Chapter one addressed the problem, objectives, and the main hypothesis.

Chapter 2 literature review: in which the concepts of biodiversity, importance, and loss are defined, the agro-ecological zones of the west bank, brief characterization of the Jenin district, a description of the range lands of the west bank and the effect of grazing as a major threat on biodiversity were discussed. Chapter 3 Materials and methods: which describes the selection of sampling area, sampling sites, the way that arthropod population was assessed?

Chapter 4 Results and discussion: in which the main results were discussed. While in chapter 5 conclusions and recommendations were stated.

Chapter two

Literature review

2.1 Concepts of biodiversity

Biodiversity can be defined in many ways, the most important definitions are:

“Biological diversity or biodiversity refers to the variety of life forms: the different plants, animals and microorganisms, the genes they contain, and the ecosystem they form” (DEST, 1993).

U.S. Congress Office of Technology Assessment “Technologies to Maintain Biological Diversity” 1987 defines biological diversity as: “Biological diversity is the variety and variability among living organisms and the ecological complexes in which they occur” (CBC, 2000)

D.B. Jensen, M. Torn, and J. Harte, "In Our Own Hands: A Strategy for Conserving Biological Diversity in California," 1990 defines biological diversity as “biological diversity means the full range of variety and variability within and among living organisms and the ecological complexes in which they occur, and encompasses ecosystem or community diversity, species diversity, and genetic diversity.” (CBC, 2000).

But the most widely used definition is that of the International Union for Conservation of Nature (IUCN) in the United Nations Earth Summit in Rio de Janeiro which is “The variability among living organisms from all sources including, *inter alia*, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems” (United Nations –Treaty series, 1993).

There are three levels of biodiversity: genetic, species, and ecosystem. These levels are all interrelated.

2.1.1. Genetic diversity:

Genetic diversity is the variety present at the level of genes, which are the building blocks that determine how an organism will develop and what its traits and abilities will be. Genetic diversity can be measured at many different levels, including population, species, community, and biome. The amount of diversity at the genetic level is important because it represents the raw material for evolution and adaptation. More genetic diversity in a species or population means a greater ability for some of the individuals in it to adapt to changes in the environment. Less diversity leads to uniformity, which is a problem in the long term.

2.1.2. Species diversity:

Species are well known distinct units of diversity, and are relatively easy to identify by eye in the field, they are also easier to conceptualize, so biodiversity studies typically focus on species. Each species have a particular "role" in the ecosystem, so the addition or loss of single species may have consequences for the system as a whole so conservation efforts will focus on species.

2.1.3. Ecosystem diversity:

The term "ecosystem" represents all levels greater than species: associations, communities, ecosystems, and the like, Ecosystem-level theory deals with species distributions and community patterns, the role and function of key species, and combines species functions and interactions, this level is the least understood level.

2.2 The importance of biodiversity

Biodiversity is very important to humans because nature and biodiversity provide services such: clean water to drink, clean air to breathe, soil for agriculture, the pollinating effect of many insects and much more is provided for us. Species diversity include potential sources of food, fiber, fuel, ornamentals, antibiotics, pharmaceuticals, and other products that satisfy human needs (Kim and Weaver, 1994).

Biodiversity performs a variety of ecological services, vegetation cover of a forest or grassland prevents soil erosion, control flooding by enhancing infiltration and reducing water run off, biodiversity in agricultural systems performs services such as: food production, fiber, fuel, recycling of nutrients, control of local microclimate, regulation of local hydrological processes, and regulation of the abundance of undesirable organisms (Altieri and Nicholls, 1999).

The number of plant and animal species on which human society depends is very narrow. Twenty species of plants and five species of animals account for over 90 % of all human sustenance and international commerce in foodstuffs, 100 species covers 98% of important economic plants and animals, and a thousand species will include most cultivated and useful plants and animals which means that only 0.01% (1000 of 10 million) of all biodiversity has economic value to humans (Solbrig, 1994). The world's population obtains about 90% of its calories from 20 crop species. Four of them (rice, maize, wheat and potato) account for 50% of total calorie intake (Madeley and Warnock, 1995).

2.3 The loss of biodiversity

The major cause of biodiversity loss is human actions that transform natural landscapes, and transform habitats. These activities include direct actions such as farming, forestry, and livestock rising, and activities as industrialization whose by-products may pollute the soil and water (Solbring, 1994).

Two levels of causes of biodiversity loss have been identified (MoA and UNDP, 2003), the immediate causes: habitat alteration and loss, over-harvesting and usage, species and disease introduction, and pollution and climate change, and the underlying causes of biodiversity loss: demographic change, inequality and poverty, public policies, market, and

politics, macroeconomic policies and structures, and social change and development biases.

Severe loss of habitats endangers biodiversity and leads to extinction of many species, the process of extinction may be identified by biological or environmental factors operating on habitat and ecosystem disturbances caused by activities of a single species, *Homo sapiens*. (Kim and Weaver, 1994). Developing Countries generally lack incentives to conserve biodiversity, while plenty of incentives exist to destroy biodiversity (Alders, 1994).

Biodiversity in Palestine suffers from several threats:

- **Israeli occupation:** the Israeli occupation is the first challenge to Palestinian biodiversity through its policies of land confiscation for settlements, by-pass roads, military bases, and finally the apartheid wall, which destroys the natural habitats; prevent the movement of animals, and increase population and, agricultural, grazing pressure on other areas (ARIJ1997, Isaac, Wolf, and Quba'a 2005, Dagher, 2006, Sawalha, 2005).
- **Overgrazing:** over grazing by small ruminants (sheep and goat) is one of principal causes of biodiversity loss and desertification in the West Bank due to the limited areas of rangelands, and the increasing numbers of livestock which increases the pressure on the available pastures beyond the carrying capacity especially during the growing season and fruiting which leads to the decrease in seed production of forage plants and shrubs leading to the removal of many palatable plants and the dominance of unpalatable plants such as *Sarcopoterium spinosum* (Thorny burnet) (Orenstein,(n .d), ARIJ, 1997, Isaac, Wolf, and Quba'a, 2005).
- **Agricultural practices:** the growing population of the West Bank needs much more food to be produced; this results in the presence of intensive agriculture, both horizontally by introducing more lands for agriculture which results to threaten wild life and wild species, and vertically by intensification in the use of agricultural inputs (machinery, improved varieties, fertilizers, pesticides, wateretc) (Orenstein, (n.d); ARIJ, 1997, Isaac, Wolf, and Quba'a, 2005).
- **Other threats:** there are many other factors that limit biodiversity conservation in Palestine including: small area with limited resources, lack of understanding of the concepts of agro biodiversity conservation, lack of qualified personnel, limited natural, personnel, financial, information resources,. Solid waste accumulation, severe drought, and lack of laws and legislations concerning biodiversity protection (Isaac, Wolf, and Quba'a, 2005, Sawalha, 2005).

2.4 Agro-ecological zones of the West Bank

The area of Palestine is 27000 km², of which about 5856 km² in the West Bank and 365 km² in Gaza Strip. The West Bank is divided into four Agro-Ecological Zones (ARIJ, 1997; PEnA1999; Hrimat, Isacc, Abu Amereyh, Ghatas, and Mhesen2002; Ali-Shtayeh, Jamous, and Hamad 2003; Isaac, Wolf, and Quba'a, 2005) which are:

1. The semi-costal region: which represents the northwest part of the West Bank as apart of Jenin and Tulkarm districts, with an area of 474 thousand dunums (8.4% of

the West Bank) with large plain areas, with a maximum elevation of about 300 meter above sea level, and dominated by fruit trees, vegetables and field crops planting in general.

2. The central highlands region: which extends from Jenin in north to Hebron (Daheria) in South, with an area of 3.2101million dunums (56.7% of the West Bank) dominant soil type is Terra Rossa, rain fed agriculture is dominant in this region (fruit trees and field crops). This region is dominated by *Qurqus calliprinos*, *Ciratonia siliqua*, *Pistatia palestina*, *Pistacia lentiscus*, *Sarcopoterium spinosum*, *Prosopis farcata*, *Inula viscosa*, *Phragmites australis*, *Moricandia nitens* and *Convonvolous oleifolium*.
3. The eastern slopes region: extends from eastern Jenin in the north alongside the western ghore, with an area of 1.577 million dunum (27.8% of the West Bank) with a Sharpe slope from 700 meter above sea level to 150 meter below sea level. This region is considered as natural range land with some barley planting, with natural plants dominated such as: *Sarcopoterium spinosum*, *Majorana syriaca*, *Artemisia herba alba*, *Eryngum creticum*, *Orchis anatolicus*, *Ranunculus asiaticusa*, *Lotus peregrinus* *Ononis natrix* and *Caparis spinosa*.
4. The Jordan valley region: Which extends alongside the Dead Sea with an area of 400.3 thousand dunums (7.1% of the West Bank) with an elevation of 200-300 meter below sea level. Dominated by Irrigated agriculture (fruit trees and vegetables), the natural plants dominant are: *Atriplex halimus*, *Sarcopoterium spinosum*, *Ziziphus spina-christi*, *Suaeda asphaltica*, *Anabsis setifera*, *Zilla spinosa*, *Prosopis farcata*, and *Calotropis procera*.

2.5 Ecological characterization of Jenin district

Jenin district is located in the northern part of the West Bank. It is bounded by Nablus district from south, Tulkarm from south west, and the green line from other directions. The district is located between 90and 750 meter above sea level, with an area of 592 km².

Jenin district is considered one of the best agricultural areas of Palestine because of the soil fertility and availability of water.

The topography of Jenin district can be divided into three areas, the eastern slopes, mountain crests, and western slopes. The eastern slopes are located between the Jordan valley and the central highland mountain a crest form the watershed line and separate the eastern and western slopes. Altitudes range on average between500-650 meter above sea level. The western slopes, characterized by gentle slopes, have elevation ranges between 100 and 400 meters above sea level.

The climate of Jenin district is governed by its position on the eastern Mediterranean. The district is characterized by its moderate and rainy winter, hot and dry summer. The mean annual rain fall in Jenin district is 528 mm. The amount of rain fall decreases from 778 mm at UM-Elrihan station in the west to 286mm at Raba station in the east of the district. According to data from Jenin Agricultural Department the western parts of Jenin district has greater amounts of rain fall because of the northern location and the greater exposure to sea level (Fig.2.1).

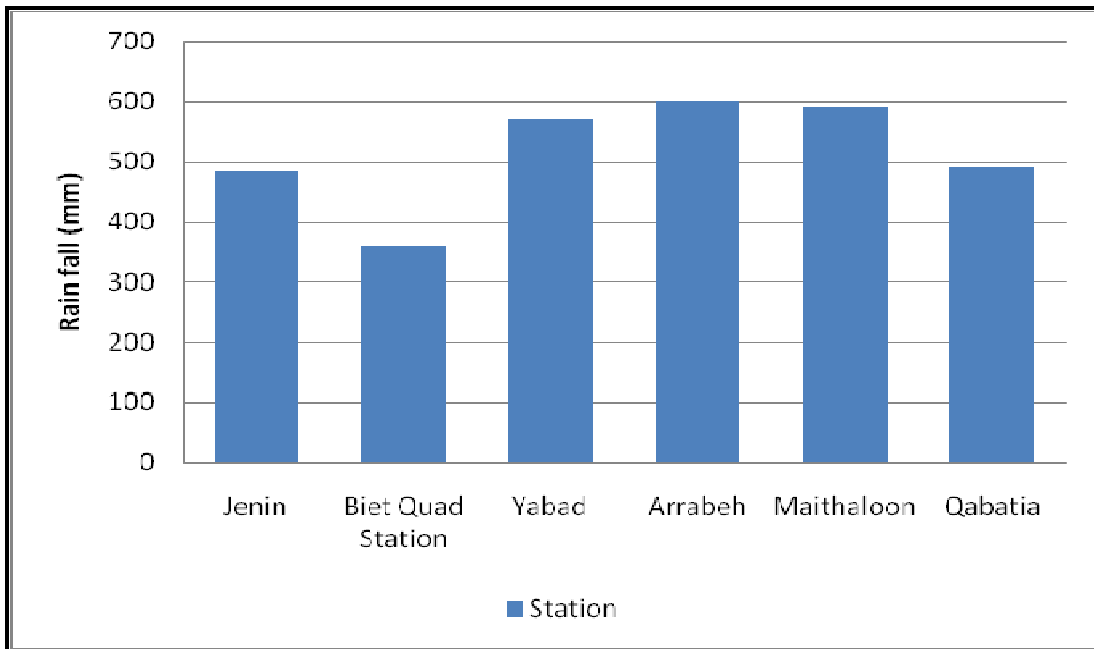


Fig. 2.1: Mean annual rain fall for 20 years from different stations in the Jenin district (Jenin department of agriculture, 2007)

The rainy season starts in the middle of October and continues to the end of April, 80 % of annual rain fall occurs during November through February. Snow fall is rare in Jenin district.

The average maximum temperature at Beit Quad weather station over the last 42 years was 27.1°C (Fig.2.2), while the average minimum temperature was 13.5 °C (ARIJ, 1996).

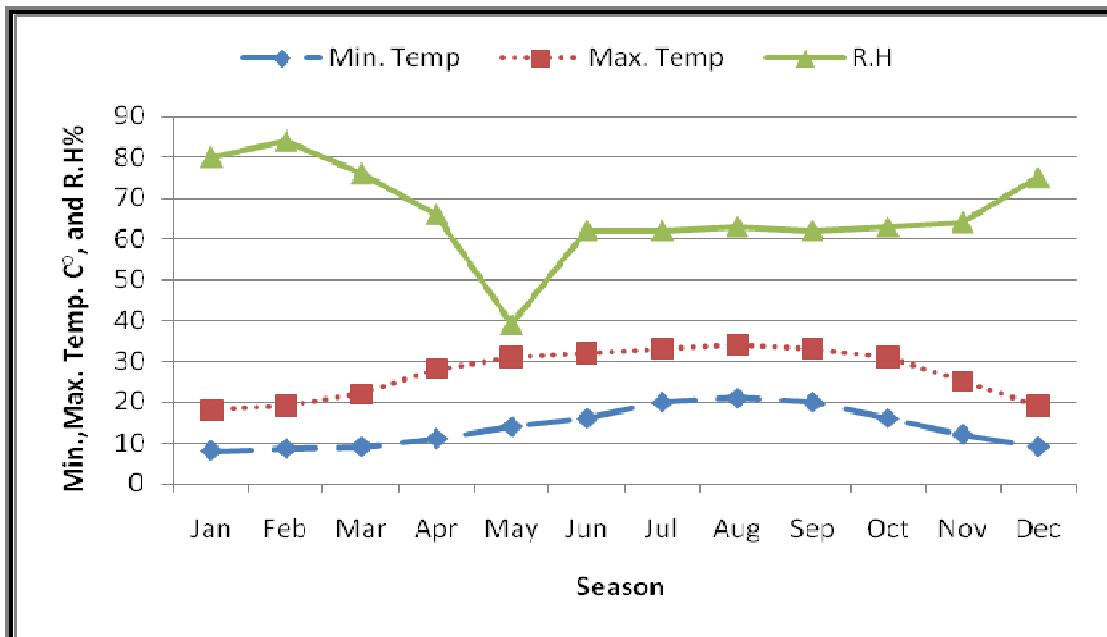


Fig.2.2: Mean Monthly Maximum, Minimum, & Relative Humidity at Beit Quad Weather Station for 42 years. (Jenin department of agriculture, 2007)

The wind direction lies between southwest and north west, being more northerly during the summer, with an average daily wind speed of 9.2 Km/hour from June to August at Biet Quad weather station while in winter the mean daily wind speed from December to February is 7.7 Km/hour at Beit Quad weather station.

2.6 Agro-climatic regions of the Jenin district

The district can be divided into three areas according to annual rain fall and cropping patterns:

- Eastern area: with an annual rain fall of about 300 mm and dominated by rain-fed agriculture with a crop rotation includes winter and summer field crops and summer vegetables. Arrana, Jalboun, Deir–Ghazzala, Beit Quad, Deir Abu Da'if and Umm Et-Tut are some villages in this area.
- Southeastern area: with an average annual rain fall higher than in the eastern area which varies between 350 and 500 mm and dominated by cereal cultivation and other field crops in addition to olive and almond trees. El- Zababdeh, Maithalun, Siris, Jadida, Sanur, and Qabatia with some irrigation wells found in the last two villages.
- North and northwestern area: the average annual rain fall ranges between 300 and 400 mm. Rain fed crops, irrigated vegetables in open fields and in plastic houses are cultivated in this part of the district. Agricultural wells are the main source of water for irrigation. Jalama, Kufr Dan, El Yamun, Burqin, and Sialt El Harthia villages are located in this area.
- West and west southern area: with an average annual rain fall ranges between 600-700 mm, with dominant cultivation of rain fed stone fruits, olive trees, vegetables, field crops. This part includes many of agricultural villages and towns such as A'rraba, Ya'bad, A'jja, and Silat El-Daher.

2.7 Range lands of Palestine

Natural grazing areas of about 2180000 dunums are present which comprises about 35% of the total area of West Bank and Gaza strip, of which about 69% in the eastern slopes region (Isaac, Wolf, and Qubq'a2005, Mohamad,2005).

The farming systems of the area are:

- Sedentary: farmers live in villages, Bedouin settled on own land and their flocks are grazed locally, with no seasonal movement.
- Nomadic: Bedouins with no village base who do not own or rent land and who move around to look for water and range nearly all year long.

Range lands of Palestine have been greatly affected by Israeli colonies and urbanization. Seven hundred thousand dunums of total grazing area are accessible to Palestinian livestock owners; the other is currently inaccessible due to land confiscation for Israeli settlements, natural reserves, and military basis, with water shortage as a serious problem.

Due to the environmental diversity of the West Bank natural grazing lands have highly diverse plant species especially range plants, where there are 114 families of flora with 2483 species. While the dominant plant families are Compositae with 96 genera and 260 species, Graminae with 87 genera and 268 species, Cruciferae with 63 genera and 124 species, Labiateae with 23 genera and 99 species, Liliaceae with 23 genera and 97 species. Trifolium which is used as forage plants contains 40 species; Medicago genus contains 22 species and trigonilla genus which contains 18 species (Bragheeth, 1995).

The number of sheep and goat present in West Bank are 1103742 heads (PCBS, 2004/2005), Hebron and Jenin Districts have 40.87% of the total number, 26.67% (294382 heads) in Hebron and 14.2% (157573 heads) in Jenin District. A small proportion of these ruminants were raised totally under shed conditions while most of livestock utilize rangeland to obtain part of its feed requirements (Mohamad, 2005)

Rangeland of the West Bank suffer from a severe deterioration, due to variation of rainfall, overgrazing, improper grazing time, uses of trees and shrubs as fuel source, and the cultivation of marginal land zone.

The absence of range management leads to the depletion of many shrubs, grasses and forages such as palatable shrubs of Retma and *Artemisia spp*, some *Vicia spp* which belongs to Papilionaceae family, and *Hordium spp* in Graminae family and to the dominant of *Sarcopoterium spinosum* (Thorny burnet) (Isaac, Wolf, and Quba'a, 2005, ARIJ,1997). Over grazing by Goats and Sheep is one of the principle causes of desertification and loss of biodiversity in the West Bank due to the loss of plant cover which leads to decreased infiltration and retention of rain water into the ground and therefore increases soil erosion (ARIJ, 1997).

2.8 Arthropods

Arthropods are invertebrates, that is, they have no backbone, and rely instead on an external covering called an exoskeleton. They get their name from their jointed (arthros) legs (podos). (Moldenke, (n.d), Heimler and Daniel, 1987). Arthropods range in size from microscopic to several inches in length. They include insects; such as springtails, beetles and ants, crustaceans; such as sow bugs, arachnids; such as spiders and mites, myriapods; such as centipedes, millipedes, and scorpions.

Arthropods constitutes about 64.5 % of species numbers from all major groups of organisms (about 1.7million), coleoptera (23.8%), lipidoptera (8.9 %), hymnoptera (7.7 %), diptera (7.1 %) other insects (8.9 %) of global total organisms (Hawksworth and Ritchie, 1993).

Arthropods can contribute to the sustainable use of natural resources as they shred organic material, stimulate microbial activity, mix microbes with their food, mineralize plant nutrients, enhance soil aggregation, increase pollination, stimulate the succession of species, and control pests.

2.9 Effect of grazing on biodiversity

Grazing by livestock can alter local plant species richness but, the observed responses are dependent on numerous factors including resource availability, plant community composition (Dorrough, Moxham, Turner, and Sutter, 2006).

The direct effect of grazing occurs by the selective removal of plant tissues or species; while indirect effects on botanical composition and species diversity can occur when selective grazing on dominant species reduces their vigor and presence, which favors the spread of less competitive but more grazing-tolerant plants (Sternberg, Gutman, Perovolotsky, Ungar and Kigel, 2000). Natural grasslands may be extensively modified by grazing from domesticated livestock (Watkinson and Ormerod, 2001).

In systems with a long history of pastoralism (grazing-determined systems), grazing is required to maintain species diversity, this grazing stress and evolutionary time (relating to the length of grazing history) is responsible for the very high values of species diversity recorded in northern Israel (Perovolotsky, 1994).

Both the plant and animal biodiversity depends critically upon the level of grazing. Too much grazing may often lead to land degradation and the loss of biodiversity, while too little grazing may lead to succession from grassland to woodland and the loss of the grassland habitat. Not only is the level of grazing important, but also the timing and the animals species involved (Watkinson and Ormerod, 2001).

According to (Shugart, 1998) there are two types of external factors limiting the biomass of plants, the first one was stress, involving the conditions that restrict plant productivity (shortage of light, water, mineral nutrient,...etc). The second was disturbances involving partial or total destruction of plant biomass (activities of herbivores, diseases, fire, frosts ...etc).

Severe grazing (inappropriate grazing season or excessive stocking rates) remove vegetation, reduces litter, and destroys biological crusts that protect soil from wind and water erosion. The composition of vegetation and physical properties of the soil may also be altered. If the impacts are severe enough, critical thresholds of ecosystem functioning may be crossed, altering water availability, energy, and nutrient supplies and causing ecosystem degradation (Pyke, 1999).

There is increasing concern that the loss of biodiversity caused by intensive practices disturbs ecosystem functioning and sustainability of grazing systems, therefore management practices that modify invertebrate assemblages also risk interfering with these essential ecosystem processes and the sustainability of further production (Reid, 2006).

Grazing is thought to reduce the species richness and abundance of invertebrates and supports more species due to declining plant biomass and vegetation complexity (Reid, 2006, Dennis et al, 2004).

There is a significant effect of grazing on species of various arthropod taxa; sensitivity of grazing management is related to taxon and trophic level. The most marked direct effect was detected on small, herbivorous leafhoppers. Vegetation structure was important for small, herbivorous species and these indirect effects from grazing also influenced the distribution of webs and species composition of web building spiders. The degree to which scattered paddock trees contribute to the conservation of terrestrial invertebrate biodiversity studied in Australia and found a significant differences in assemblages of invertebrates under trees compared with surrounding grazed pastures, more native invertebrates and more species of invertebrates were found under trees compared with surrounding grazed pastures (Oliver, Pearce, Greenslade, Penelope, and Bitton, 2006).

Carabidae (ground beetles) and Staphylinidae (rove beetles) are considered as indicators of habitat disturbances, such as drainage of wetlands, or grassland for grazing animals, and their monitoring could provide one measure of ecosystem sustainability if intensive grazing management systems expand or intensify in the future (Byers, Baker, Davidson, Hoebeke, and Sanderson, 2000).

More Coleoptera species occurred in the tall sward (an average of nine species) continuously grazed as opposed to ensiled subplots more beetle species but fewer individuals. Species composition of ground (Carabidae) and rove (Staphylinidae) beetles varied between treatments more than the arithmetic differences in species numbers (Dennis et al, 2004).

However the effect of grazing on large, ground-active beetles namely ground and above ground rove beetles and wolf spiders was found to be not consistent (Dennis, 2003).

Alfalfa weevil egg numbers were reduced by an average of 55% by late fall cutting and 67% by grazing in winter by cattle compared with the ungrazed treatment. However, peak larva numbers were reduced by an average of 25% with grazing (Dowdy, Berberet, Stritzke, Caddel, and Mcnew, 1992). Grazing reduced larva numbers of (Alfalfa weevil (Coleoptera: curculionidae)) by about 60% three weeks after grazing (Buntin and Bonton, 1996).

Heavily grazed assemblages were dominated by a group of large web-spinners were most sensitive to grazing preferring ungrazed control because of their dependence of rigid plant structure (Gibson, Hambler, and Brown, 1992). Grazing reduced aphid populations by 66% to 90% when numbers exceeded 1 aphid per stem while populations were not significantly reduced by grazing when numbers did not exceed 1 per stem (Buntin and Bonton, 1997).

Species richness of bees, eumenid wasps and sphecid wasps did not differ between grazed, non, or abandoned orchards meadows while abundance of sphecid wasps was significantly higher on abandoned than managed (grazed or mowed) orchard meadows (Steffan and Leschke, 2003).

Species richness and abundance of butterflies were enhanced by the low stocking rate compared to the moderate stocking rate, which shows that butterfly diversity on grasslands increased within three years by reducing stocking rates (Varies, Tallowin, Dulphy, Sayer, and Diana, 2005).

Butterflies and grasshoppers showed lower species richness and abundance at moderate stocking rate, in contrast, the number of ground-dwelling arthropod groups was higher at moderate stocking rate (Varies, Tallowin, Dulphy, Sayer, and Diana, 2004). Species richness and total abundance of butterflies and moths were highest in abandoned pastures, both for all species and grassland-preferring species (Poyry, Lindgren, Salminen and Kuussaari, 2004).

The population of endangered butterfly *Euphydryas aurinia* in southwest phinland quickly recovered when the grazing pressure by cattle on host plant of the larva *Succisa pratensis* was lowered (Saarinen, Jantunen, and Valtonen, 2005).

Intense grazing pressure during the nymphal period resulted in a temporary reduction in nymphal density of spittle bug (Homoptera: Cercopidae) but additional hatching of eggs allowed the density to increase. Intense grazing during the last generation of adults, prior to the start of the dry season drastically reduced the nymphal population (Hewitt, 1998).

The number of species on the terrestrial surface may face a significant and substantial reduction in response to environmental change, which affects some species positively and others negatively were a higher level of extinction of species will occur than might be expected from comparable past climatic change operating on flora and fauna inhabiting intact and continuous natural landscape (Shugart, 1998).

Chapter three

Materials and methods

3.1 Selection of sampling area

To perform this study a sampling site in the central part of Jenin district (Mirkeh village) were selected for many reasons like the presence and abundance of many plant and animal species, the availability of natural grazing area which can be protected (protected natural grassland treatment) to study the impact of grazing on arthropod diversity, the availability of some needed metrological data from nearby stations.

Ecological characterization of the study area was done in a preliminary study of the area, which included the identification of different plant and animal species present, and identification of the various rare and threatened plant and animal species present.

For the characterization of the study area several field visits and observation tours were made, photograph documentation, information on wild animals present in the area was also collected from people living in the area including farmers and shepherds. Species identification was done with the aid of plant and animal taxonomy keys and references

Mirkeh sampling area (Fig3.1) is located 13 km south west of Jenin city with an area of 25 square kilometers; Longitude: 035°14'07 E , Latitude : 32°24'16 N , Elevation:361 M above sea level; and annual rainfall 600 mm. Ecosystem type is considered as Mediterranean shrub land.

3.2 Sampling site

Two sampling sites were selected within the western part of sampling area (Fig. 3.2, Table 3.1); each site was used as a land use treatment for sampling arthropods:

- Site 1: protected natural grassland.
- Site 2: grazing grassland.

Three 250 square meter plots were selected at each site (10m*25m).

3.3 Sampling of arthropods population

Pitfall trapping method (passive collection method) was used for collecting Arthropods.

Four pitfall traps were placed in each plot in a systematic manner, 3 pitfalls in a row in the center of the replicate plots at approximately 5metres apart, 5 meters away from both sides of the plots and the fourth pitfall were placed 3 meters at right of the middle one.

Pitfall Traps are 450 ml containers (cups, jars, plastic bottles, tins) with relatively small diameter that are sunk into the ground so that the lip of the trap is flush with the ground surface (Figure 3.3) (Briefs, 1994, Ministry of Environment, lands and Parks, 1998).

Pitfall Traps were made of 500 ml plastic containers (10 cm in diameter and 10 cm deep) as inner container and a 2-liter cola bottles as outer containers (William and Marcos, 1994).

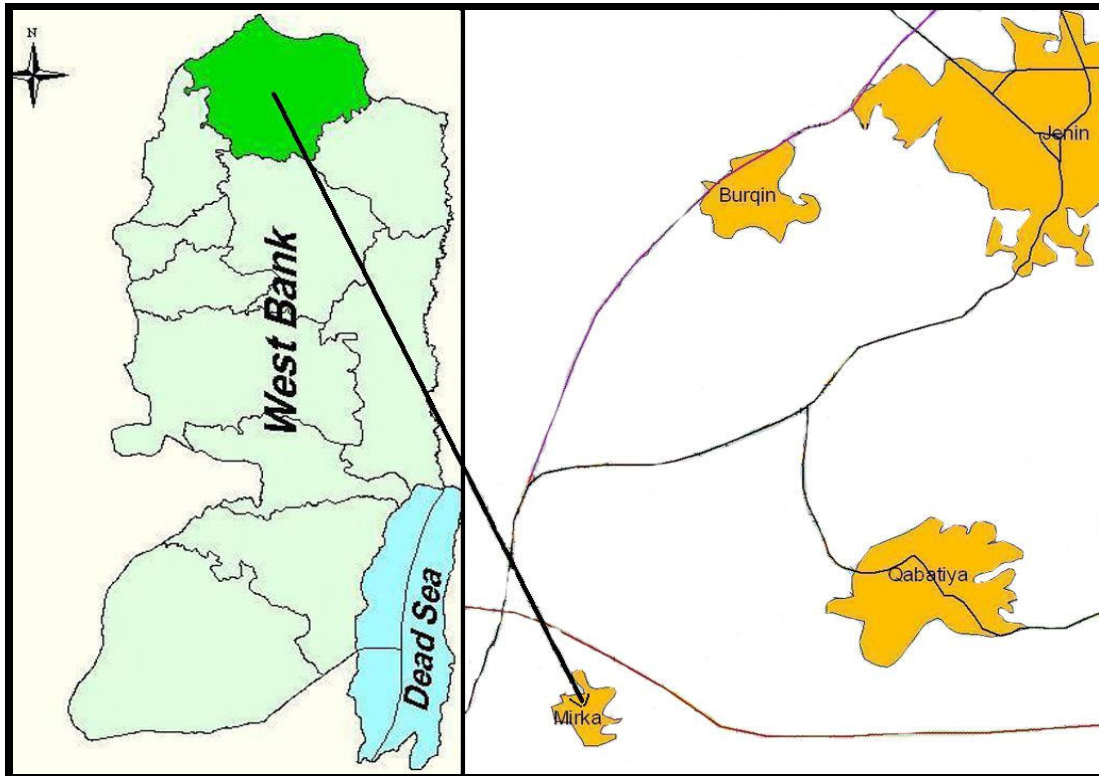


Fig.3.1: Mirkeh sampling area.

Table 3.1: Physical and biotic characteristics of the study sites.

Site	Natural grassland	Grazing grassland
Ecosystem type	Semi-arid Mediterranean (32°24'00 N, 35°14'43 E)	Semi-arid Mediterranean (32°24'14 N, 035°14'09 E)
Elevation (a.s.l)	361 m	337 m
Vegetation formation	Dwarf-shrubs of <i>Cupressus sempervirens</i> associated with herbaceous (chiefly annual) plant species	Dwarf-shrubs of <i>Sarcopoterium spinosum</i> and <i>Cupressus sempervirens</i> associated with herbaceous (chiefly annual) plant species
Percent of rocks	No rocks	About 20%
Direction	East-west direction facing north	South-north direction facing west



Fig.3.2: Sampling sites in Mirkeh sampling area.

3.4 Setting up traps

- Traps were installed in the ground by using a trowel to cut through and remove the roots and soil to create a whole 12 cm in diameter and 15 cm in depth which is closely approximates the size of the outer cola bottle.
- The excavated root and soil were removed about 10 m from the site to minimize disturbance but some soil were retained to refill around the outside of the trap.
- The pitfall trap (cola bottle) was placed in the hole and the outside surrounding edge filled with soil.
- A second cup (500 ml plastic container) was placed inside the first one.
- A 100ml diluted (50%) mono ethylene glycol (MEG) with the formula (HCO_2C_2) was added to the pitfall traps for each servicing time.
- A piece of banana as bait for arthropods was placed in the traps.
- A 1 cm mesh screen 16*16 cm was placed on top to prevent small animals & plant debris to fall in the trap.
- A pitfall cover made of 1 * 16 * 16 cm wooden board with four nails were fixed over the mesh screen with 2.5 cm apart to permit arthropods to pass easily.
- Four traps were used for each of the three replicates at each site. Twelve traps were used for each site.
- Arthropods were sampled once in the middle (7-21) of July 2006, November 2006, February 2007, and April 2007 for summer, autumn, winter, and spring seasons respectively.
- At each sampling occasion, the pitfall traps were opened for two consecutive weeks (day and night). After one week the containers were removed and replaced by fresh containers.
- Arthropods counts for each trap were recorded and then the total count for each plot (total of four pitfall traps) were calculated as the population level for each division of arthropods



Fig. 3.3: Pitfall trap with cover.

3.5 Sample processing

At sampling times total arthropods found in each pitfall trap were transferred to 10cm in diameter, 5 cm depth plastic containers and preserved in mono ethylene glycol until further classification. Total arthropods were counted and counts recorded. Collected arthropods were divided in to different taxonomic groups as follows: Total arthropods, beetles, ants, total insects, spiders, and non-insect arthropods and numbers of each group recorded.

Samples of each different group were preserved in a 30 ml glass vials with 100 % mono ethylene glycol for sample identification and specimen preparation. The rest of the samples collected from each replication were preserved in 125 ml plastic containers with 100% mono ethylene glycol for further study. Samples were further processed and photos were taken for the specimens (Fig. 3.4) at Al-Quds University and Biodiversity & Environmental Research Center (BERC), Til, Nablus for identification.

3.6 Climatic data

Several climatic parameters needed for the study were recorded, including annual precipitation which was recorded starting from October 2006 using a common plastic rain gauge. Minimum, maximum temperature and relative humidity were recorded using thermo-hydrograph (FRANZ KETTERER, meteorologische instrumente, D-79294 sölden b. frbg. ibrg) starting on 20th November 2006, the data were inserted to an excel file for data processing and drawing of needed curves. Monthly precipitation, min and max air temperatures and relative humidity were also obtained from a nearby metrological station (Az-Zababdeh station).



Figure 3.4: Sample processing at BERC.

3.7 Determination of Edaphic factors

In order to determine Edaphic factors (Soil moisture, Soil texture, Soil pH, Nutrients), soil samples (Figure3.5) were collected using a trowel to dig the soil to about 15 cm in depth, one composite sample (from three plots) of about 1.5 Kg were taken from each treatment in each season (15th of each sampling month) to have finally 8 soil samples (4 Seasons *2 Treatments)

The samples were sieved to take away the clods, gravels, straw and grass. A50 g net weight of soil were taken from each sample to determine the moisture content of the soil at each collection time using a digital scale (TANITA DIGITAL SCALE, PROFESSIONAL MINI, model1479, Japan), the samples were air dried and weighed until there is no weight decrease, then the moisture content were calculated as :

Moisture content percentage = $100 - (\text{dry wt} / \text{net wt}) * 100\%$.

The rest of soil samples were sent to Al Quds University for physical and chemical analysis

A500 gram soil sample were taken and analyzed to determine soil physical properties of the soil (percentage of Sand, Silt, and Clay (Soil Texture))

Soil pH was determined in a: 1:1 (soil: water) suspension according to McLean, 1982, Ca was determined by titration, Nitrogen, Ammonia was determined using Nessler Method and Nitrate by using Cadmium Reduction Method, While Phosphorus was determined using (Ascorbic Acid) or Orthophosphate Method.



Fig. 3.5: Soil samples collected.

3.8 Data analysis

Data for collected arthropods were inserted to excel file designed especially for data entry, the data was classified to different arthropod taxa. After that the variables were identified in SPSS file using different variables (Treatment and Season as independent variables, Total arthropods, Beetles, Ants, Total insects, Spiders, Non-insect arthropods as dependent variables).

Data was analyzed to determine if there are significant differences between treatments using Chi Square test and to determine if there are significant differences between seasons using One Way Analysis of Variance (ANOVA).of SPSS. (SPSS Inc., (1999)).

Chapter four

Results and discussion

As a result of the current study the study area were ecologically characterized, which included the climatic and ecological features of Mirkeh sampling site, identification of different plant and animal species present, and identification of the various rare and threatened plant and animal species present, which were done through many field visits and observation tours to the study area, photograph documentation, information on wild animals present in the area was also collected from people living in the area including farmers and shepherds. Species identification was done with the aid of plant and animal taxonomy keys and references.

While small animals that present in the site, the impact of some environmental factors on arthropod diversity, the impact of grazing on arthropod diversity, and seasonal differences in the distribution of the arthropods were as a result of one year study using pitfall traps in collecting the arthropods.

4.1 Main ecological features of Mirkeh sampling site as a representative of northern part of the West Bank.

The main ecological features of Mirkeh sampling site as representative of the northern part of West Bank is discussed bellow.

4.1.1. Key climatic and ecological features of Mirkeh sampling site.

Results for the main environmental factors were recorded in the study site, and the same parameters were recorded from a nearby station at Az-Zababdeh station of Palestinian agricultural relief committee's center in the east of the study area. Fig. 4.1 represent minimum and maximum temperatures of the site starting from November 2006 to April 2007, minimum monthly temperature of 7.5 C° was recorded on January 2007 while maximum monthly minimum temperature of 14.8 C° was recorded on November 2006. A maximum of 24.59 C° was recorded in November while it reaches its minimum on January 2006.

Extreme monthly minimum relative humidity recorded is 55.13% on April and 72.7 % on February 2007, while extreme maximum monthly relative humidity were 90.1% on November 2006 and 99.57% on February 2007. (Fig4.2)

The rainy season starts on October .13th 2006, and extends for 7 months with 37 rainy days and 563 mm total amount .which is less than the mean annual rainfall of the site. February 2007 with the highest amount (194 mm) followed by January 2007 with 115 mm, while April with 19 mm is the lowest.

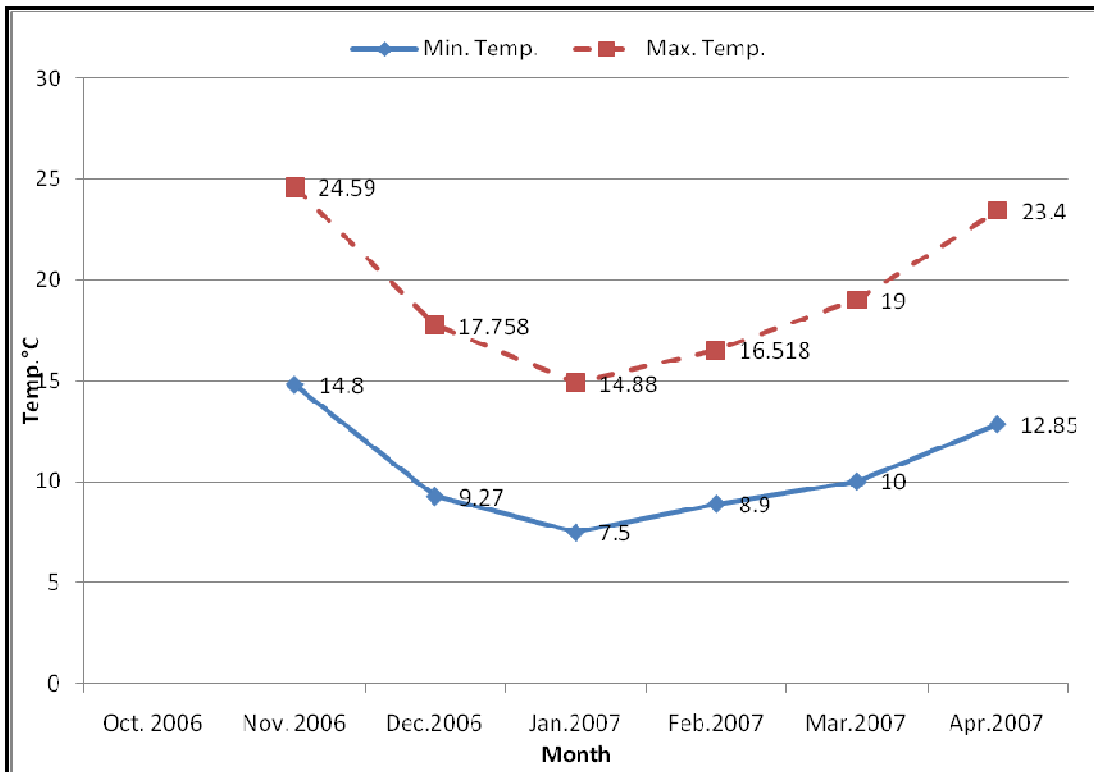


Fig. 4.1: Minimum and maximum temperature recorded at Mirkeh sampling site.

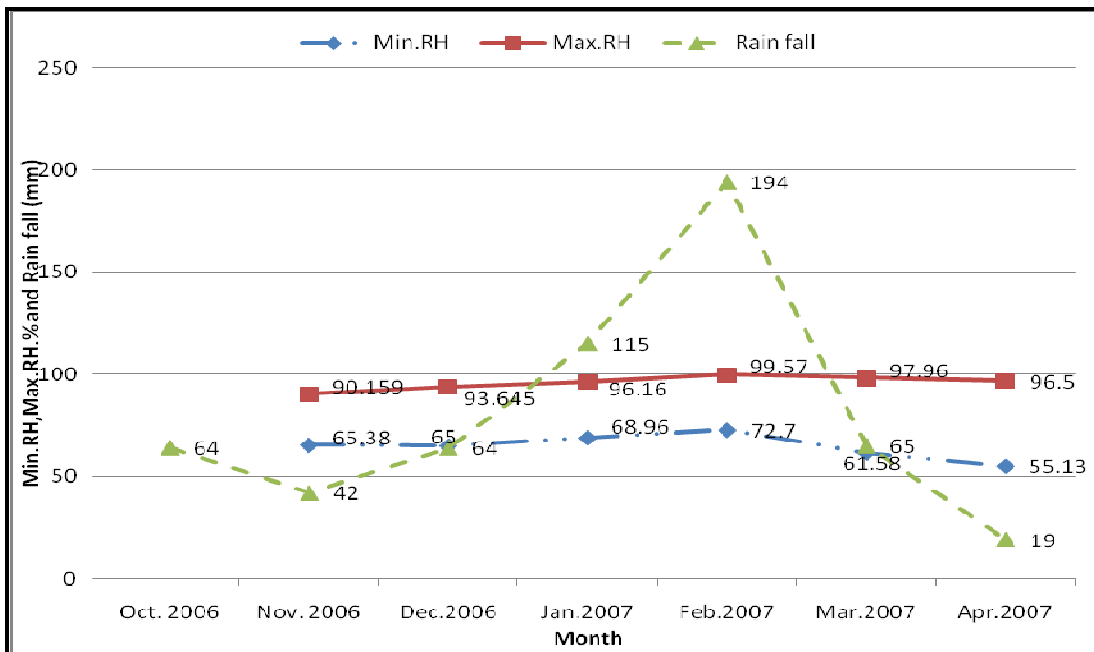


Fig. 4.2: Minimum, maximum relative humidity and rainfall recorded at Mirkeh sampling site.

According to the website of Az-Zababdeh Station meteorological data base (www.mimris.org). August is the warmest month at Az-Zababdeh village with 33.8 C° maximum monthly temperature, 19.8 C° minimum monthly temperature and 26.5 C° average

monthly temperature, while January is the coldest during the season with 4.4C°, 17.2 C°, and 10.1 C° monthly Min., Max, and Avg. temperatures respectively (Fig. 4.3).

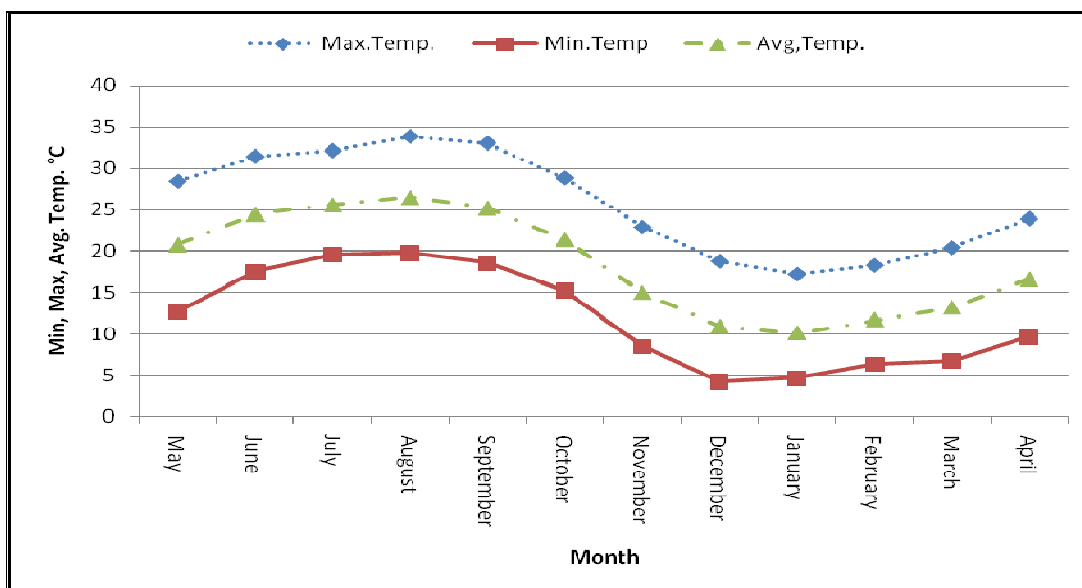


Fig. 4.3: Minimum, maximum and average temperature recorded at Az-Zababdeh Station. Maximum average relative humidity recorded at Az-Zababdeh station was 72.3 % on February while the minimum average was 55.7% on December. As at Mirkeh sampling site the rainy season starts on October .13th.2006, and extends for 7 months with 385.5 mm total amount. (Fig. 4.4)

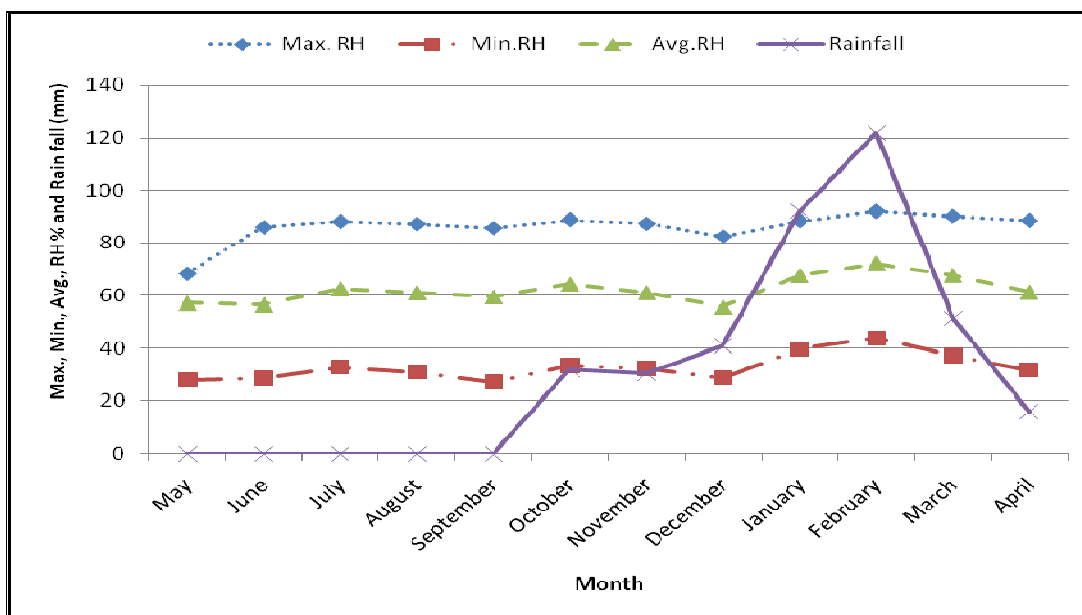


Fig. 4.4: Minimum, Maximum and average Relative Humidity and Rainfall recorded at Az-Zababdeh Station.

Soil moisture content of the two treatments were calculated for the four seasons and the results are represented in (Table 4.1), while other soil physical properties (sand, silt and clay percentage, and soil texture) of the two treatments of Mirkeh sampling site were

analysed, results shows that the soil type in the two sites are sandy loam with(69 %, 17 % , and 14 % sand, silt and clay percentage respectively for treatment one, and 66 %, 19 %, and 15 % sand, silt and clay percentage respectively for treatment two.

Table 4.1: Different seasonal soil moisture percentage of Mirkeh sampling site.

Season	Treatment	
	Protected grassland	Grazing grassland
Summer	7.7	6.8
Autumn	17.2	15.8
Winter	19	16
Spring	10.6	7.8

While Table (4.2) represents Soil chemical properties (PH, Ca,P₂O₅, P, and NH₄) for different seasons of Mirkeh sampling site.

Table 4.2. Different seasonal soil chemical properties of Mirkeh sampling site.

Season Prop.	Summer		Autumn		Winter		Spring	
	Prot.	Graz.	Prot.	Graz..	Prot.	Graz.	Prot.	Graz.
pH	8.04	7.88	7.6	7.88	7.88	7.77	7.88	7.92
Ca(PPM)	64.13	72.14	96.2	112.2	88.2	136.3	112.2	96.2
P ₂ O ₅ (PPM)	0.54	0.11	0.08	0.03	0.2	0	0.17	0.2
P(PPM)	0.24	0.05	0.03	0.01	0.09	0	0.08	0.09
NH ₄ (PPM)	1.93	1.75	1.95	1.23	3.09	1.09	2.4	2.33

4.1.2. Key different species of plants and animals present in Mirkeh sampling area.

Several field visits and observation tours were made during the last year, photograph documentation of the flora and fauna of the site were made when it is possible and some plant samples were collected for identification which were done with the aid of some taxonomic and field guide references in zoology and botany were used in identification of animal and Plant species, of these references (Ali-shtayeh, Jamous, and Hamad 2003, Alon, 1992, Helou and Al-Qatan, 1997, Atrash, 2003, Kharoob, 1992, Meinert, 1993, Morita, 1997, Toman and Felix, 1974)

Jenin District with its location in the northern part of the West Bank is governed by the Mediterranean climate with rainy winter and hot dry summer, the mean annual rainfall of the district is 528 mm, the mean annual rainfall is highest in west (778mm) at Um-El-rihan decreasing as we went east (286mm) at Raba (ARIJ, 1996). Different soil types are recognized in the district ranging from brown alluvial soils in the plains to terra rossa, brown forest soils, and rendizina in the central highlands (Ali-shtayeh, Jamous, and Hamad 2003), the district is located within the Simi-costal region in the north and the rest of the district lies within the central high land region.

These variations in location, topography, climatic conditions, and soils in addition to Human impact on plant cover leads to the richness, diversity, and variation in the plant cover of the district which in turn leads to diverse habitats for different animals (Ali-shtayeh and Jamous, 2002a)

Dry land rain fed agriculture is dominated in this region (Fruit trees and Field crops). Mirkeh sampling area lies in the center of Jenin district and has many plant and animal species which represents the flora and fauna of the district.

4.1.2.1. Plant species present in Mirkeh sampling area

Different dominant Plant species of trees, and shrubs comprising 15 plant families with Anacardiaceae, Oleaceae, Pinaceae and Rosaceae as the most important families (Appendix 4.1). While herbaceous plants with economic (food and feed resources, wood products and fuel), medicinal, and social (research, education, monitoring, and recreation, religious and cultural values) importance present in the sampling area comprising 22 plant families with Compositae, Cruciferae, Gramineae, Labiatae, Papilionaceae are the most important (Appendix 4.2)

Mirkeh sampling area is considered as agro biodiversity rich area due to the dominance of many important fruit trees, Olive trees(*Olea europea (L)*) are the most abundant tree in the region followed by almond(*Amygdalus communis(L)*), common fig(*Ficus carica (L)*), prickly pear(*Opuntia ficus indica(Mill)*) and some scattered trees of sumach(*Rhus coriaria*) and carob(*Ceratonia siliqua (L)*) which have the importance as food trees in addition to their secondary values as wood and aesthetic plants.

Atlantic pistachio (*Pistatia atlantica Desf*) and Palestinian pistachio(*Pistacia palestina Boiss*), mastic tree(*Pistacia lentiscus*) which are present in the area with small numbers scattered in the eastern part of Mirkeh sampling area, cypress(*Cupressus sempervirens*), Jerusalem(*Pinus halepensis Mill*) and Brutian pine(*Pinus brutia Ten*) which present in larger numbers and are the main components of the forests present in the area and field borders as wind breaks, other unpalatable shrubs present in the area like burnet(*Sarcopoterium spinosum*) and caper(*Capparis spinosa(L)*) which are dominant in the grazing hilly lands and field borders. Trees of less importance are present in large numbers as Palestinian buckthorn(*Rhamnus palestinus Boss*) and thorny broom(*Calycotome villosa*), while trees with small number present like Storax tree(*Styrax officinalis (L)*), African Rue(*Ruta chalepensis L*), Spiny Thorn(*Crataegus aronia (L)*), and Syrian christi-thorn(*Ziziphus spina-christi(L)*).

As the population of the West Bank increases the demand for food increases leading to an increase importance of agriculture so the farmers give their attention to the establishment of new fields of trees especially Olive and other trees like stone fruits (Almond, Peach, plum, Cherry ...etc), Fig, and Grapes through land reclamation whether by heavy machinery or by using other practices like plowing, fire, and herbicide usage, in addition to the removal of non-useful plants (Atlantic and Palestinian Pistachio, Mastic tree, Palestinian Buckthorn, Thorny Broom, Storax Tree, African Rue, Spiny Thorn, and Syrian Christi-thorn) from their fields which leads to the increase in food trees areas and the decrease of other trees numbers.

Agricultural practices like (Plowing, herbicide usage), land reclamation, cutting of trees For wood and fuel, non-controlled collection of food and medicinal plants, and high grazing pressure on grasslands are considered as the major threats of biodiversity in the area.



Fig. 4.5: Carob Tree; *Ceratonia siliqua* of Caesalpinaceae family.



Fig. 4.6: Storax Tree; *Styrax officinalis* (L) of Styracaceae family.



Fig. 4.7: Palestinian Buckthorn; *Rhamnus palestinus* Boss of Rhamnaceae family.



Fig. 4.8: Caper Shrub; *Capparis spinosa* (L) of Caparidaceae family.

Different annual herbaceous plants present are considered as food resources like (Arum; *Arum palaestinum*, Persian Cyclamen; *Cyclamen persicum*, Fennel; *Foeniculum vulgare*, and Least Mallow; *Malva parviflora*), many medicinal plants present like (Wild Chamomile; *Matricaria chamomile*, Roman Nettle; *Urtica pilulifera*, Thyme; *Thymus bovei*, and Sage; *Salvia palestina*) a study of BERC “Ethno botany :Ethno botany of Palestinian herbal medicine in the Northern West Bank and Gaza Strip :Review and comprehensive field study” shows that 253 species belonging to 82 families were still used as medicinal plants, while 125 plants permanently still used, sage; *Salvia fruticosa* Mill, chamomile; *Matricaria aurea*, and thyme; *Majorana syriaca* are the most commonly used plants as indicated by percent respondents of the study respectively (72% , 54%, 31%) and 55 % of medicinal plants of the northern west bank mentioned in this study are wild plants (Ali-shtayah, and Jamous, 2006).

Aesthetic plants like (Anemone; *Anemone coronaria* (L), Persian cyclamen; *Cyclamen persicum*, Pheasant’s eye; *Adonis aestivalis* (L), Hollyhock; *Alcea setosa*, Sword-flag; *Gladiolus aleppicus* Boiss, Blue lupine; *Lupin pilosus* (L), Dwarf iris; *Iris reticulata*, and Daffodil; *Narcissus Spp*) are present, in addition to the highly important feed plants like (Vetches; *Vicia spp*, Wild pea; *Pisum fulvum* (Smith), Wild clover; *Trifolium tomentosum*, wild medics; *Medicago spp.*, Ryegrass; *Lolium rigidum*, Wild oat; *Avena sterilis*, Wild barley; *Hordium bulbosum* L, Johnson grass; *Sorghum halepensis* Pers, and Aegilops; *Aegilops buncialis* Vis).



Fig. 4.9: Purple clover; *Trifolium purpureum* of Papilionaceae family.



Fig. 4.10: Aegilops; *Aegilops buncialis* Vis of Gramineae family.



Fig. 4.11: Medicinal Squill; *Urginea maritima* of Liliaceae family.



Fig. 4.12: Anemone; *Anemone coronaria* (L) of Ranunculaceae family.

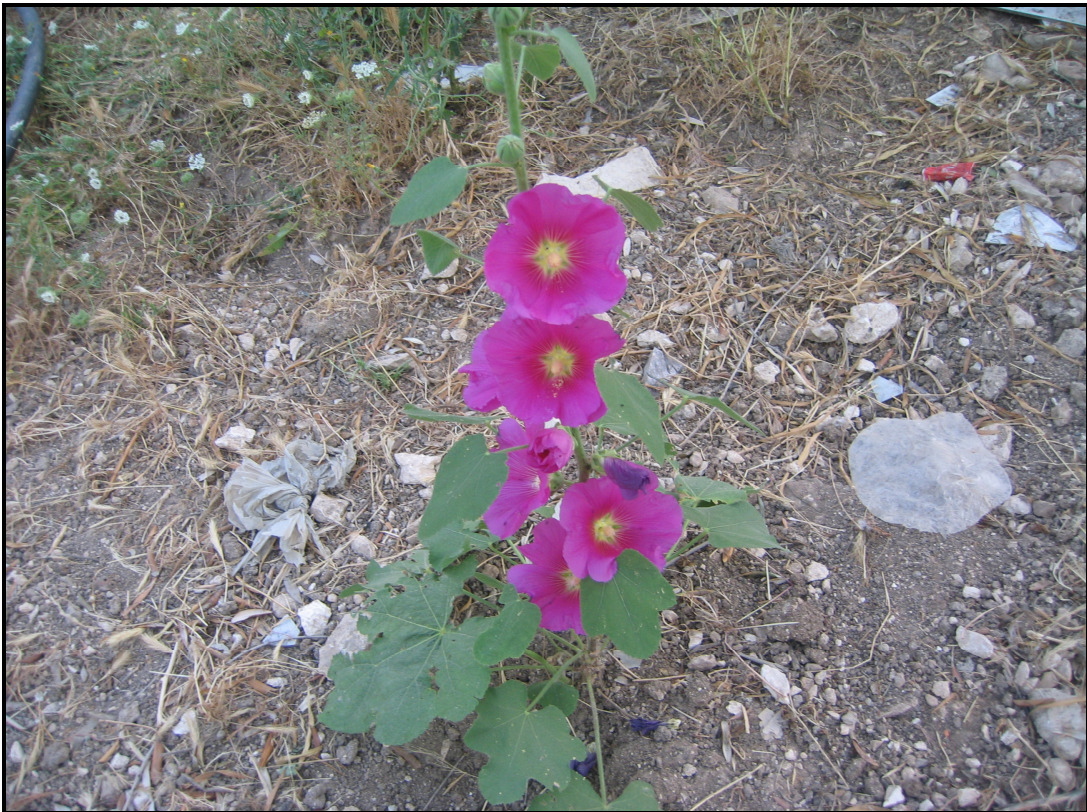


Fig. 4.13: Hollyhock; *Alcea setosa* of Malvaceae family.

4.1.2.2. Animal species present in Mirkeh sampling area

The most abundant animal species present in Mirkeh sampling area are birds, mammals, reptiles, and small animals.

4.1.2.2.1. Birds

The key bird species of Mirkeh sampling area whether they are resident, winter visitors or migrants are members of the common 25 bird families (Appendix 4.3).

Abundant bird species around the year present in the area like (Collared Dove; *Streptopelia decaocto*, Laughing Dove; *Streptopelia senegalensis*, Common Bulbul; *Pyconotus xanthopygos*, European Blackbird; *Turdus merula*, Robin; *Erithacus rubecula*, Jay; *Garulus glandarius*, Hooded Crow; *Corvus corone*, House Sparrow; *Passer domestica*, Spanish Sparrow; *Passer hispaniolensis*, Hoopoe; *Upupa epops*, Syrian Woodpecker; *Dendrocopos syriacus*, Crested Lark; *Galerida cristata*, Common Swallow; *Hirundo rustica*, Black Red Start; *Phoenicarus ochruros*, Graceful Warbler; *Prinia gracilis*, Chiffchaff; *Fringilla coelebs*, Cattle Egret; *Bubulcus ibis*), while others are present in small numbers like (Kestrel; *Falco tinnunculus*, Chukar; *Alectoris chukar*, Little Owl; *Athene noctua*, Long-eared Owl; *Asio otus*, Palestine Sunbird; *Nectarinis osea*) but other birds which are considered as winter visitors like (Quail; *Coturnix coturnix*, Black Kite; *Milvus migrans*, Sky Lark; *Alanda arvensis*, White Wagtail; *Motacillo alba*, Stone Chat; *Saxicola torquata*, Green finch; *Carduelis chloris*, Chaffinch; *Fringilla coelebs*) are present, spring visitors like (White Stork; *Ciconia ciconia*, Black Cap; *Sylvia atricapilla*, Great Tit; *Parus major*), summer and autumn visitors (Bee-eater; *Merops apiaster*, Wood chat Shrike; *Lanius senator*, Honey Buzzard; *Pernis apivorus*).

Hunting of birds is a major cause in the decrease of some birds like Chukar, while insecticide usage is a threat to some bird species especially those birds which feed on insects like Common Swallow, White Throat Warbler, and Bee-eater, insecticide usage have an indirect effect on raptor birds like (Little Owl, Eagle Owl, Long-eared Owl, Kestrel, Sparrow-hawk, Lesser-spotted Eagle, Golden Eagle, Egyptian Vulture, Black Kite) (Ali-shtayeh and Hamad, 1995).

Some bird species has benefited from reforestation and the increase of agricultural lands (Orchards) such as: Syrian Woodpecker, Robin, European Blackbird, Great Tit, Jay, Common Bulbul, and Palestine Sunbird.



Fig. 4.14: House Sparrow; *Passer domestica* of Passeridae family.



Fig. 4.15: Kestrel; *Falco tinnunculus* of Falconidae family.



Fig. 4.16: European Blackbird; *Turdus merula* of Turdidae family.



Fig. 4.17: Robin; *Erithacus rubecula* of Turdidae family.

4.1.2.2. Mammals

Wild animals like Hedgehog; *Erinaceus europaeus concolor*, Wild Hare; *Lepus capensis syriacus*, Mountain Gazelle; *Gazella gazella*, Hyrax; *Procavia capensis*, Red fox; *Vulpes vulpes palestina*, Egyptian mongoose; *Herpestes ichneumon* Blind Mole-rat; *Spalax leucodon*, Brown Rate; *Rattus norvegicus*, House Rate; *Rattus rattus*, House Mouse; *Mus musculus*) present in Mirkeh sampling area.

4.1.2.3. Reptiles

In addition to other animals like Turtle; *Testudo graeca* (Fig. 4.18A), Agama; *Agama stellio* which live between vegetation & rocks & start their reproduction in late winter to early spring, *Chamaelo chamaeleon musae*, Geckos; *Stenodactylus sthenodactylus* and *Stenodactylus petrii*, Snakes, Lizards; *Acanthodactylus scutellatus* (Fig.4.18 B) which stay the over wintering period under the rocks and in soil pores, while they start their reproduction season late spring.



Fig. 4.18: A: Turtle; *Testudo graeca* & B: Lizzard; *Acanthodactylus scutellatus*.

4.1.3. Various rare and threatened plant and animal species present in Mirkeh sampling area

Within Mirkeh sampling area there are many threatened and rare plant species belonging to 14 plant families (Appendix 4.4), while threatened and rare birds belonging to seven bird families (Appendix 4.5). While other threatened animals are: Wild Hare; *Lepus capensis syriacus*, Mountain Gazelle; *Gazella gazella*) present in Mirkeh sampling area.

4.1.4. Key different species of small animals present in these habitats in Mirkeh sampling site.

Different invertebrates inhabit the site which are representative of the key invertebrates of Jenin district, Arthropods collected inhabit both vegetation and soil microhabitats, some are prey feeding on others like spiders using their webs as catchment's of other flying insects,

scorpions, and some beetles, while others are plant consumers like grasshoppers, bumblebee whose feed on plant nectars, others are plant liter decomposers like some beetles, ants and other insects. Beetles and ants are the major components of insects present in the site around the year (Table 4.3), while scorpions, centipedes and millipedes in addition to beetles and ants are components in the site during summer and autumn seasons.(Apendix4.6)

Table 4.3. Mean seasonal catch of different arthropods groups of Mirkeh sampling site.

Season	land use	Beetles	Ants	Spiders	Non-Insect Arthropods	Total Arthropods
Summer	protected grass land	15	176.6	22.6	49.6	282.3
	grazing grassland	14.6	122	14.3	47.6	210
Autumn	protected grass land	319.3	237.3	12	41.6	633
	grazing grassland	207.6	27.6	9	81.6	344.6
Winter	protected grass land	40	9	25	36	133
	grazing grassland	41.3	27	12.3	30.3	115.6
Spring	protected grass land	33.3	37	30	35.3	145
	grazing grassland	40.6	34.3	12	24.6	116.6

Many other canopy arthropods were found during spring and summer like Butterfly's, grasshoppers, dragon, fly's, Wasps, bumble bees, bugs, and aphids. Arthropods present in the site have different role in these habitats and ecosystem functioning.



Figure 4.19: Silk Moth; *Saturnia pyri* of Saturniidae (Silk Moths) family.



Fig. 4.20: Common Butterfly pollinating Almond Flowers.



Figure 4.21 Click Beetle; *Agrypnus notodonata* of Elateridae family



Figure 4.22: *Sacred Scarb* of Sugar-Beetle (Scarabeidae)



Fig. 4.23: Dung -Pusher Beetle; *Scarabacus sacer* of Ground Beetles (Carabidae) family



Fig. 4.24: Common Dust Beetle; *Opatrium sabulosum* of Ground Beetles (Carabidae) family



Fig. 4.25: *Pterostichus vulgaris* of Ground Beetles (Carabidae) family



Fig. 4.26: Bombardier Beetle; *Brachynus crepitans* of Ground Beetles (Carabidae) family



Fig. 4.27: *Hister fimentarius* of Prop Beetles (Histeridae) family



Fig. 4.28: Violet Ground Beetle; *Carabus violaceus* of Tiger Beetles (Cicindilidae) family

4.2. Impacts of some environmental factors on arthropods diversity

As the Mediterranean region, Mirkeh sampling site has a seasonal fluctuation in its main environmental factors. Fluctuation in environmental factors along the season causes a variation in the population of arthropods present, high population level of average total arthropods collected in autumn (633 in protected grass land and 344.67 in grazing grass land) is related to low rainfall amount and low moisture content of the soil, while the average number of arthropods decreases in winter (133 in protected grass land and 116 in grazing grass land) due to high rainfall amount, high soil moisture content and low temperatures as shown in Fig. 4.29

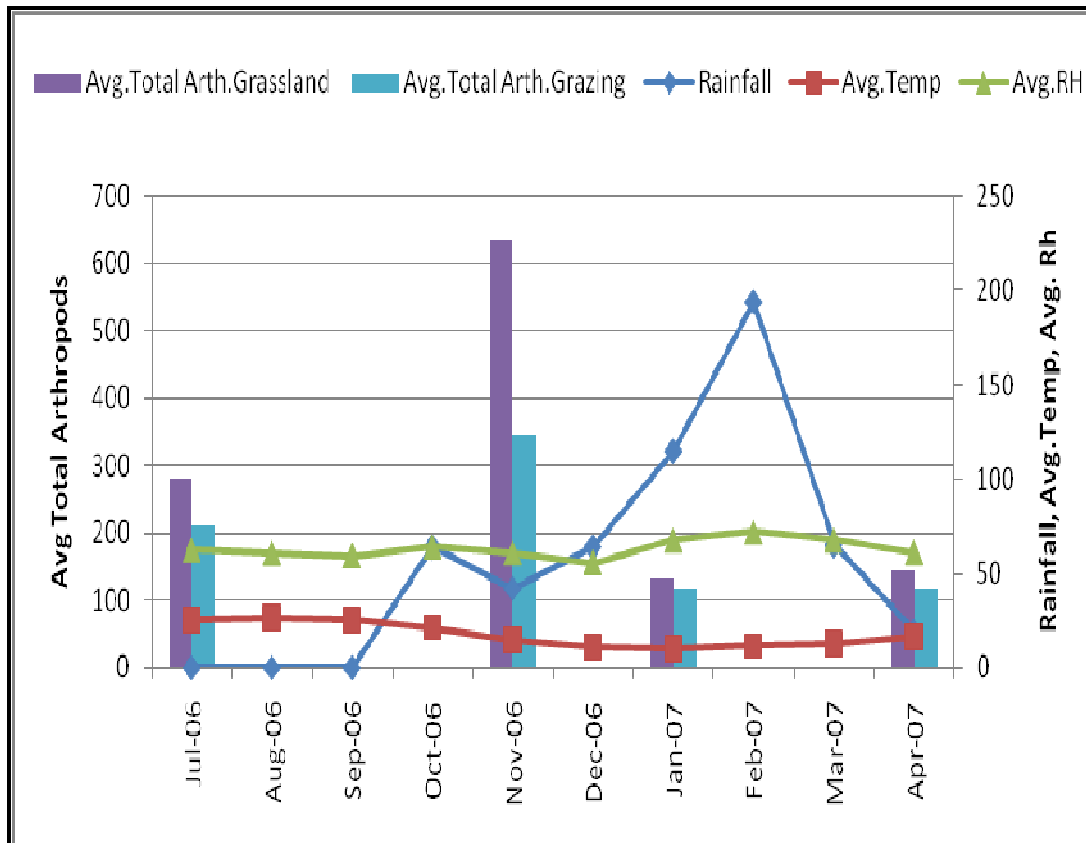


Fig. 4.29: Seasonal fluctuation of total arthropod population in relation to environmental conditions.

Average number of total insects (Fig. 4.30) has the same trend as the average number of total arthropods with peak number in autumn (579 in protected grassland and 254 in grazing grassland), winter with a minimum average number of total insects (72 in protected grassland and 73 in grazing grassland), starting to increase in spring (80 in protected grassland and 80 in grazing grassland), summer (210 in protected grassland and 149 in grazing grassland)

Average number of spiders collected shows an increase in numbers (Fig. 4.31) in winter and spring (25 and 30 in protected grass and, 12.3 and 12 in grazing grass land respectively) as relative humidity, rainfall increases, and temperature decreases.

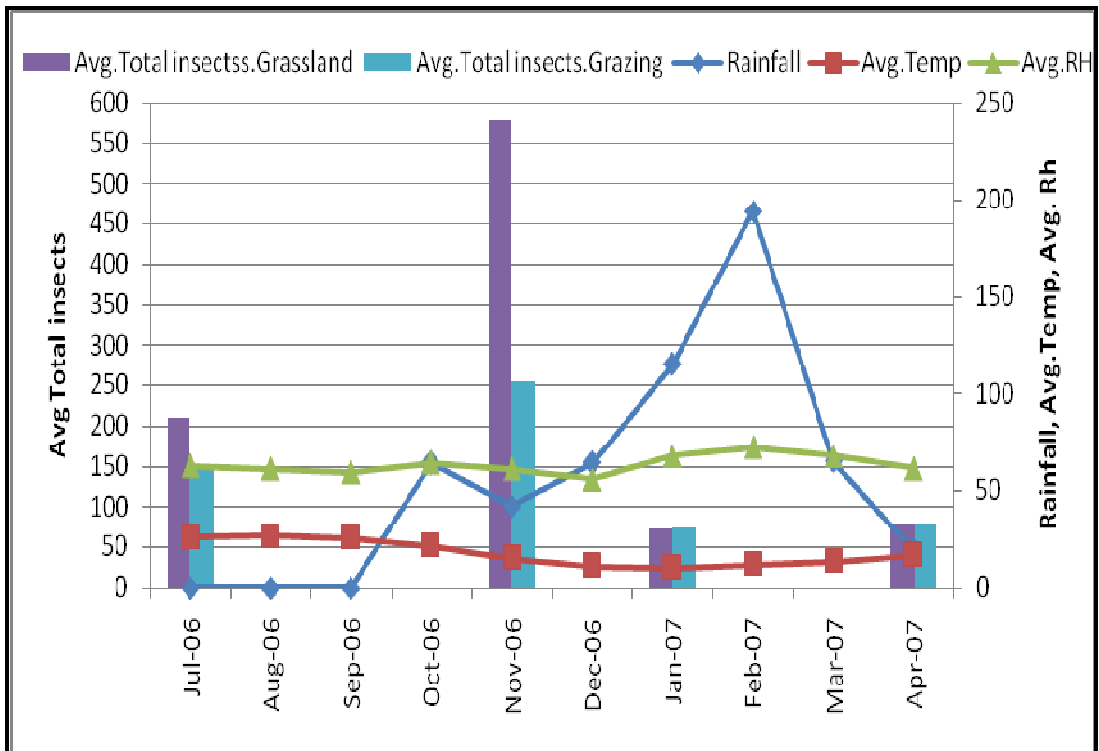


Fig. 4.30: Seasonal fluctuation of insect population in relation to environmental conditions.

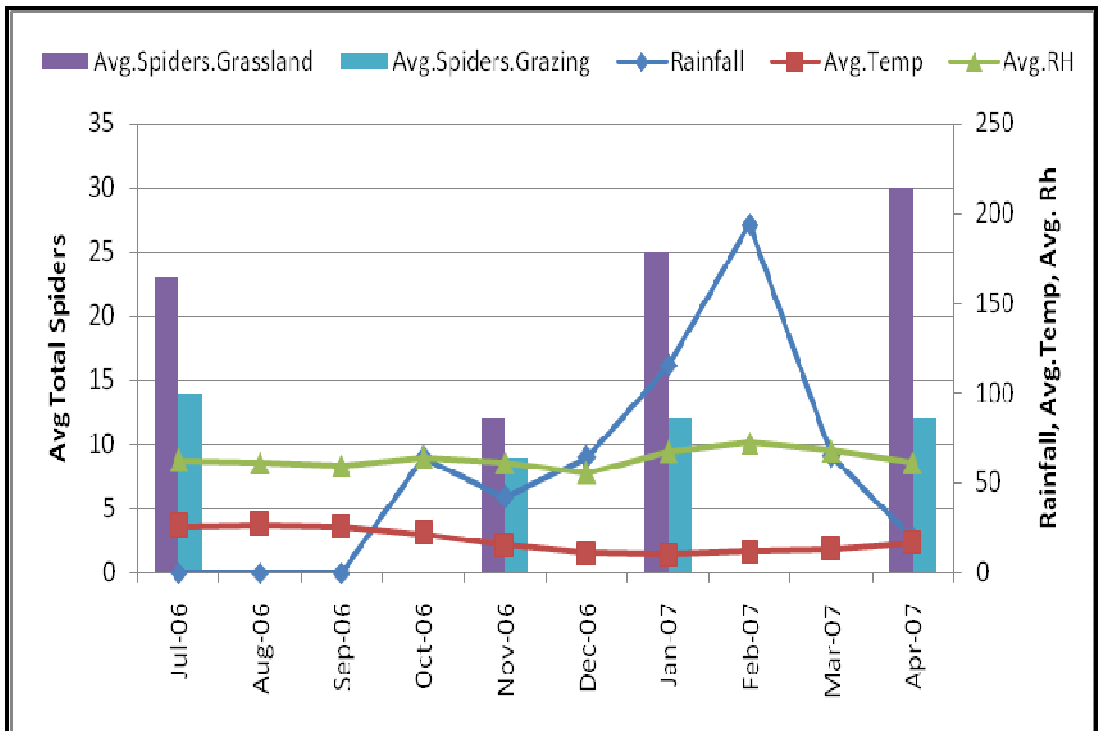


Fig. 4.31: Seasonal fluctuation of spider population in relation to environmental conditions.

4.3. Impact of grazing on arthropods diversity

Person Chi-square tests for the two treatments (Trt 1 (protected grass land) and Trt 2 (grazing grass land)) were made to detect the impact of grazing on arthropod diversity (whether there are significant differences between the two treatments (Protected and Grazing) regarding different arthropod groups collected).

Results shows no significant differences between total arthropods collected per catch from the two treatments (Chi-Square= 24, Sig. = 0.404), arthropod divisions show the same trend. Beetles with (Chi-Square= 24, Sig = 0.293), Ants with (Chi-Square= 17.33, Sig = 0.5), Total insects with (Chi-Square= 24, Sig = 0.347), Spiders with (Chi-Square= 21.333, Sig = 0.212), and Non-Insect Arthropods with (Chi-Square= 20, Sig = 0.333).

which means that grazing have no negative impact on total arthropod collected per catch or on the different arthropod groups (Beetles, Ants, Total Insects, Spiders, Non-Insect Arthropods), this is mainly because the protected treatment was protected from grazing just last season (Winter and Spring) which are the grazing seasons in the area, this will not establish the conditions that greatly affect the arthropods in the treatment like low plant cover, low moisture content, and low nutrients, grazing intensity is very low and the carrying capacity of the grazed plots were low which in turn doesn't affect arthropod diversity .

In addition arthropods collected are mainly of soil and ground arthropods which are not greatly affected by plant cover and finally by grazing as leaf and plant canopy arthropods.

These results resemble that of research conducted by Reid. M (Reid, 2006) to know the "Effect of fertilizer and grazing on grassland invertebrates" in a naturalized pasture on central tablelands of New South Wales /Australia which shows that grazing had little impact on ground dwelling invertebrates with no reduction in species richness of surface-active invertebrates, while species richness and abundance of foliage invertebrates were reduced by grazing due to declining plant biomass.

Results by Dennis. P, in a research conducted in UK "Sensitivity of upland arthropod diversity to livestock grazing vegetation structure and landform" shows that the effect of grazing on large, ground-active beetles, namely ground and rove beetles, and Wolf spiders was not consistent, which confirm my results (Dennis, 2003).

4.4. Temporal (seasonal) difference in the distribution of the arthropods

One way analysis of variance for collected arthropods shows that there are highly significant difference between seasons in the total arthropods collected per catch (sig. = 0.000) with autumn as the highest in total arthropods collected per catch (mean= 488.33) decreasing in winter (mean= 124.33), starts to increase in spring (mean=130.83), summer (mean=246) to reach its peak on autumn Fig. 4.32.

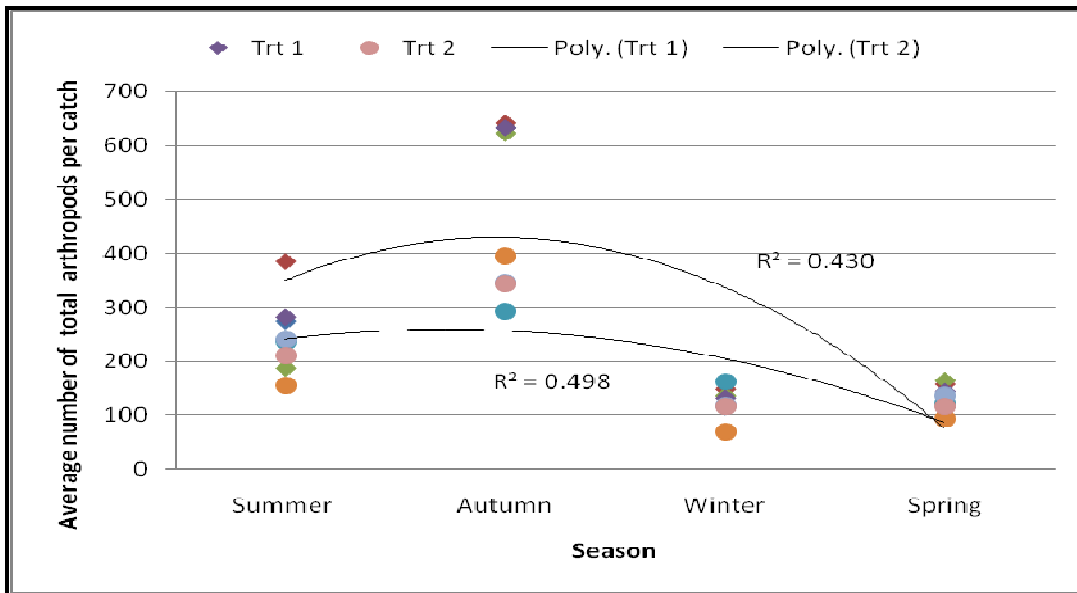


Fig. 4.32: Variation in average number of total arthropods collected around the year.

Total insects per catch have the same trend of seasonality (sig. =0.000). autumn with peak number of total insects collected per catch (mean= 416.67), decreasing to its minimum in winter (mean=72.5), starting to increase in spring (mean=79.83) and summer (mean=179.33) Figure 4.33.

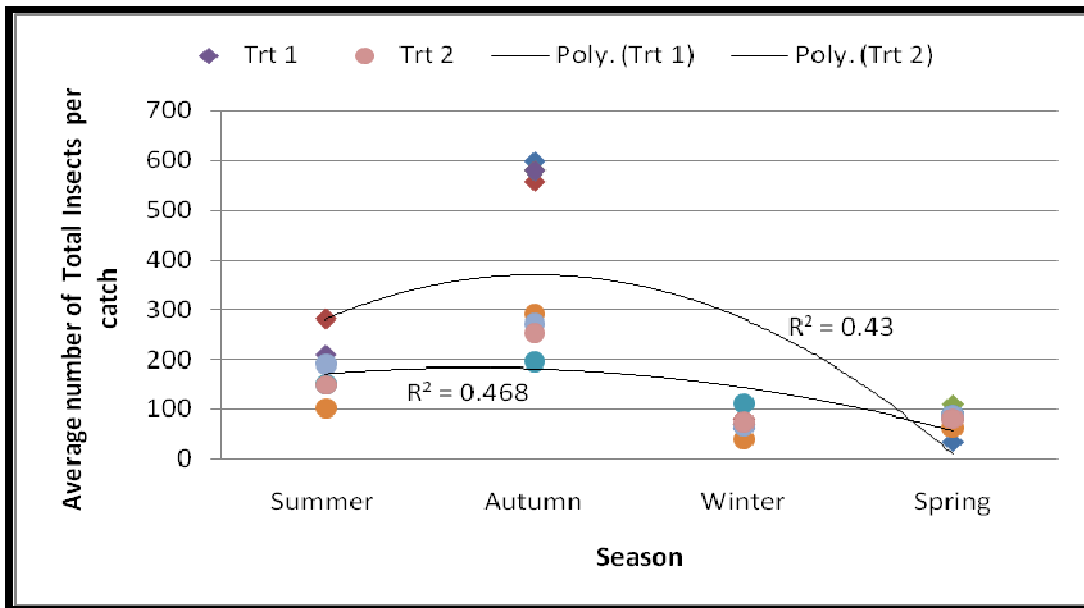


Fig. 4.33: Variation in average number of total insects collected around the year.

Beetles collected per catch have a high significant seasonality (sig. = 0.000) with autumn as the maximum population of beetles (mean= 251.5) starting to decrease in winter (mean= 40.67), spring (mean = 37) to reach its minimum in summer (mean = 14.33).Fig. 4.34.

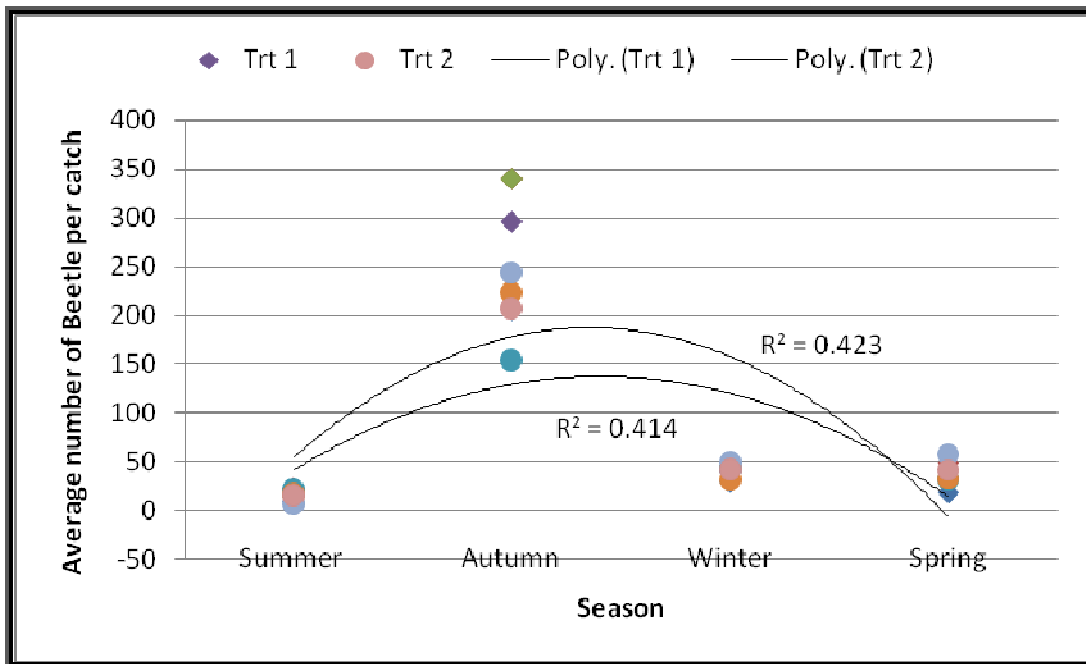


Fig. 4.34: Variation in average number of beetles collected around the year.

Ant populations have seasonal differences (sig. = 0.013) with its peak in summer (mean = 149.33) decreasing in autumn (mean = 132.5), reaches its minimum in winter (mean = 18) and starts to increase their populations in spring (mean = 35.67) Fig. 4.35.

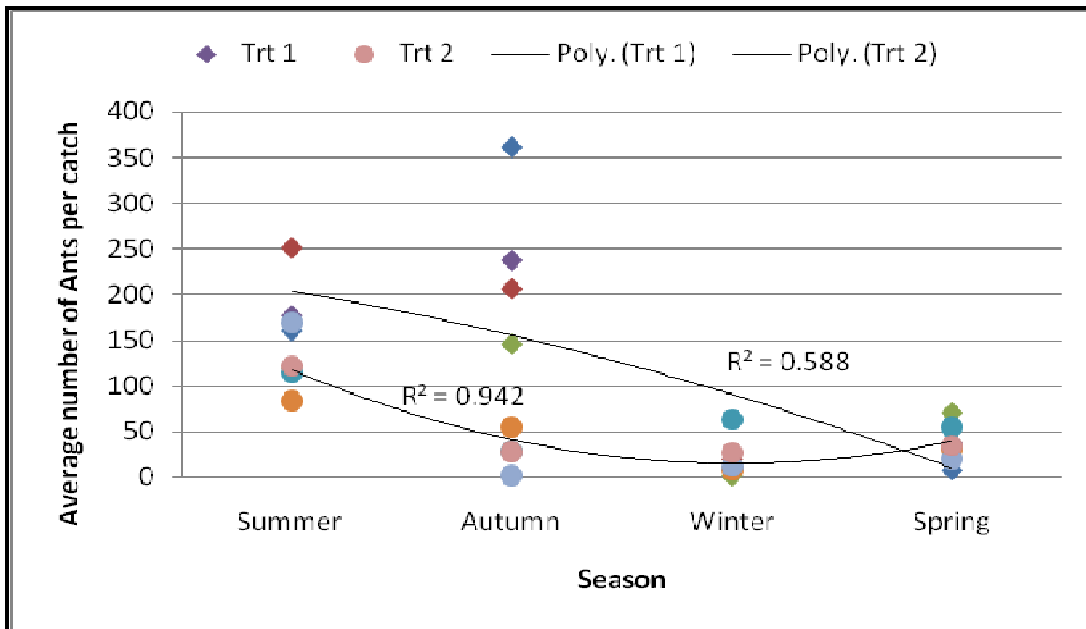


Fig.4.35: Variation in average number of ants collected around the year.

Non-insect arthropods (Spiders, Scorpions, Millipedes, and Woodlice) have a variation in their population along the season (sig= .022) with peak number of collected Non-insect

arthropods in autumn (mean =61.6) decreasing in winter (mean = 33.1), reaches its minimum in spring (mean = 30) and starts to increase in summer (mean = 48.6).Fig.4.36.

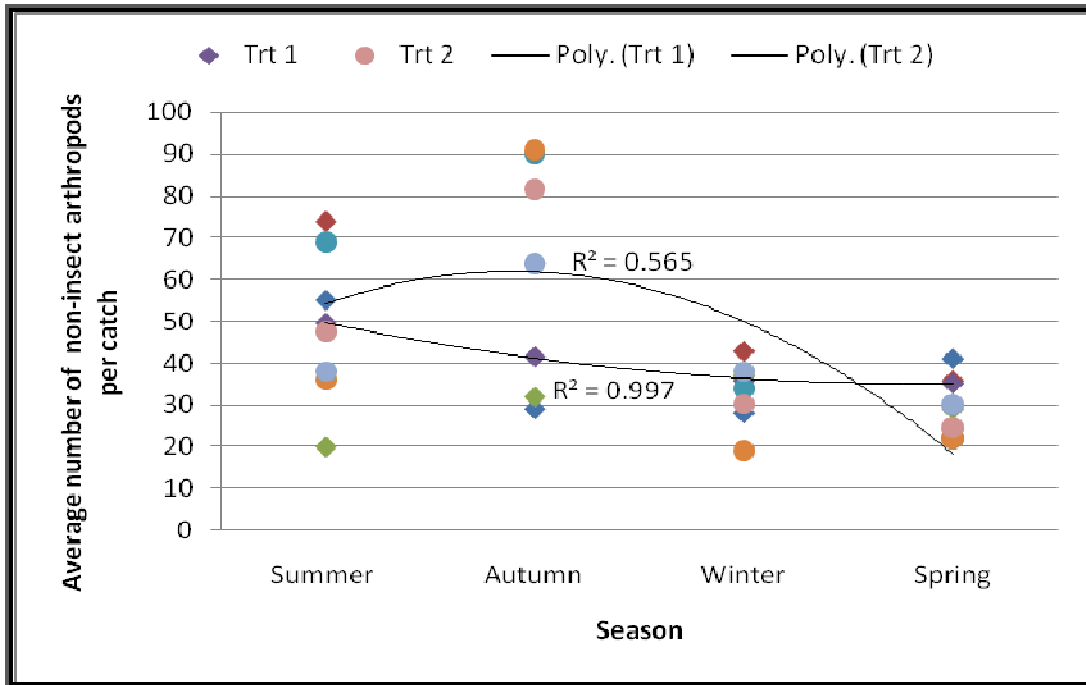


Fig. 4.36: Variation in average number of Non-insect arthropods collected around the year.

On the other hand, spiders on the contrary of all other arthropods collected have no significant differences in their populations during the different seasons (sig. = 0.142).Fig. 4.37

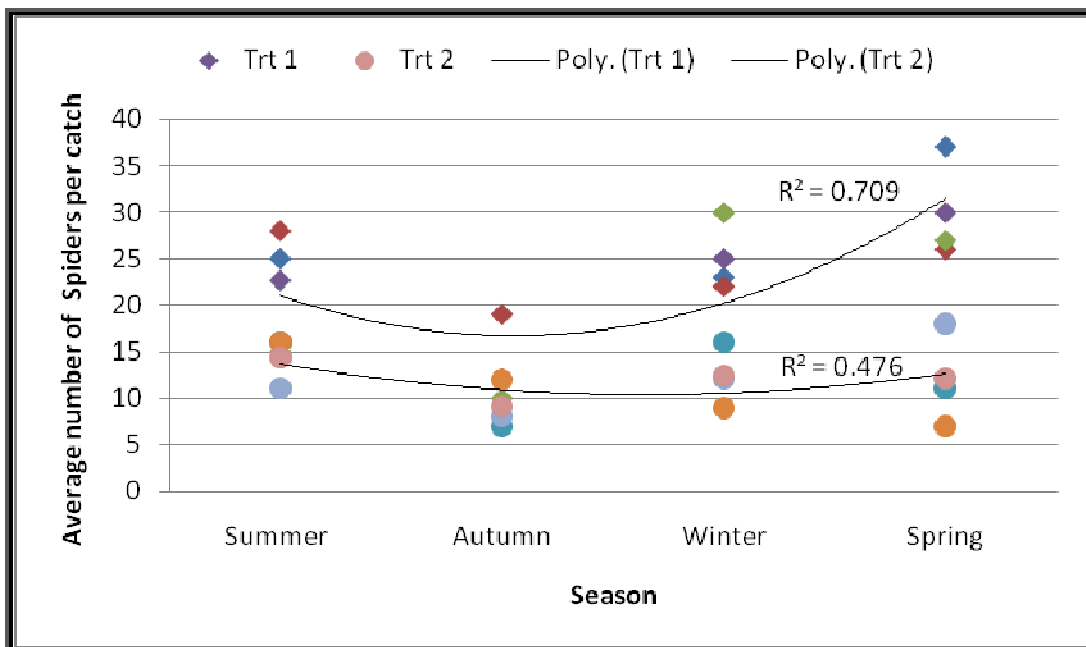


Fig. 4.37: Variation in average number of spiders collected around the year.

4.5. Major options and priorities for action

In the Palestinian National Authority there are the laws the national strategies for biodiversity conservation of the Ministry of Environmental affairs and that of Ministry of Agriculture which are concerning the protection and preserving of biodiversity, wild life and range lands, but it is worthy to mention that the current situation of overharvesting and usage, overgrazing, current agricultural practices, hunting, Israeli occupation, limited resources, lack of understanding of the concepts of agro biodiversity conservation, lack of qualified personnel, limited natural, personnel, financial, information resources,. Solid waste accumulation, severe drought, and insufficient laws and legislations concerning biodiversity protection are a major cause of biodiversity deterioration and genetic erosion in Palestine. So within the current situation of degradation and loss of biodiversity there are many actions that can be made to decrease deterioration and increase the awareness of biodiversity and wild life toward the preservation and protection, of which:

- Public Awareness of the importance of biodiversity: which is the responsibility of Ministry of Environmental affairs, Ministry of Agriculture, Ministry of Education, Palestinian Universities, Governmental and Non-Governmental organizations related to the biodiversity protection, the target of this awareness are those whom have a major role like :
 - Farmers: the farmers may have the awareness of the importance of conservation and sustainable use of agro biodiversity and its importance to them first and to the whole people and to the coming generations, so they should practice their work in a wise way without the overuse of agrochemicals(pesticides and fertilizers), use of agricultural practices that help in sustainable agriculture, use of land races and adapted plant varieties, sustainable use of pastures and rangelands and farmers may start their small scale farming system(self dependency) in sustainable way by using their own source of seeds, manure and local amendments of soil, agricultural practices and home storage and industry.
 - Women: the Palestinian women may play an important role in conservation and protection of biodiversity, through planting the local varieties of vegetables, medicinal plants and adapted fruit trees in her home garden which can be used as a food source at home which contribute in the prevention of removal of wild and medicinal plants, they may also practice some handcrafts and home made products which improve the livelihood of the rural families decreasing poverty which a reasonable cause of biodiversity deterioration.
 - Students: school students can play a very important role in preserving activities so they should have sufficient awareness of the importance of biodiversity and conservation, and they can practice some activities of preservation like school gardens which may contain many wild plants, land races, medicinal plants which can be used as practical resources in their study, small animal gardens can be established in the schools in which different animals and birds can be raised like Partridge, Quail, Hens, Pigeons, Rabbitsetc, and some economic insects may be collected in school laboratories or museums for exhibition.

- Conservation Activities: in the current situation it is worthy that the governmental and non-governmental Organizations (Ministry of Environmental Affairs, Ministry of Agriculture, Ministry of Tourism, The Palestinian Universities, other organizations and centers related to biodiversity and scientific research) play their role in preserving, protection and promoting biodiversity through the establishment and management of natural reserves in which many plant and animal species can be preserved. National seed bank can be an effective way of preserving local and introduced germplasm that can be used in breeding activities. Botanical gardens and public gardens may be other ways of conservation activities, field gene banks and community seed banks are other ways of conservation.
- Scientific and applied research: in which Palestinian universities and research centers can play their role in the preservation and use of genetic resources .through collection identification, documentation, preservation and use.
- Legislation and policies: the concerned ministries should develop their policies and legislation in order to protect, preserve, and restore biodiversity.

Chapter five

Conclusions and recommendations

5.1 Conclusions

The current study leads to the following conclusions:

- The variation in location, topography, climatic conditions, and soils leads to the richness, diversity, and variation in the plant cover of the northern part of the West Bank which in turn leads to diverse habitats for different animals.
- The area is considered rich in agro biodiversity due to the variation of plant cover and agricultural crops.
- A wide range of plant and animal species of relative importance present in the area of which many plants and animals are threatened or endangered.
- Biodiversity of the area are threatened due to several causes like: habitat alteration by humans, Israeli measures like (land confiscation for settlements, by-pass roads, military bases, and finally the apartheid wall), agricultural practices over grazing, and hunting.
- Small animals with relative importance are present in the area and their populations are affected by environmental factors, land use patterns, and seasonality.
- The current situation of overharvesting and usage, overgrazing, current agricultural practices, hunting, Israeli occupation, limited resources, lack of understanding of the concepts of agro biodiversity conservation, lack of qualified personnel, limited (natural, personnel, financial, and information) resources,. Solid waste accumulation, severe drought, and insufficient laws and legislations concerning biodiversity protection in Palestine may lead to the continuation of biodiversity degradation and loss.

5.2 Recommendations

- Other detailed studies concerning the status of biodiversity in the area must be done, the composition and abundance of plants and animals of the area may be carried out.
- The impact of different land use practices on plants and animals and the ecosystem as a whole may be studied.

- Ministry of Environmental affairs, Ministry of Agriculture, Ministry of Education, Palestinian Universities, Governmental and Non-Governmental organizations related to the biodiversity protection should intensify their efforts in the protection of biodiversity through public awareness, of target groups whom have a major role like: farmers, women, students. They may also share in biodiversity protection through the establishment of field gene banks, seed banks, public gardens, Botanical gardens, natural reserves, and protected areas.
- Farmers may contribute to biodiversity conservation through many ways of which sustainable use of natural resources, use of landraces, use of agricultural practices, natural soil amendments, and safe use of pesticides.
- Different conservation measures should be practiced from the related agencies and centers to protect and stop the loss and degradation of biodiversity in Palestine.
- The laws and legislation in Palestine should be more efficient in protecting biodiversity.
- It is worthy to update the national strategy and action plan of biodiversity conservation in Palestine.

References

- Alders, H, (1994): Towards biodiversity in politics .in: O .Solbrig, H .Emden, and P.van Oordt (Eds).Biodiversity and Global Change (pp 8-12).CAB INTERNATIONAL, UK.
- Ali-Shtayeh. and Hammad, A. (1995). Protection of Palestinian Environment .Nablus :Authors (Arabic)
- Ali-Shtayeh, M and Jamous, R. (2002a): Biodiversity: Value and Conservation .Biodiversity and Environmental Sciences Studies Series No.(1).Biodiversity &Environmental Research Center (BERC), Til, Nablus, Palestine.(in Arabic)
- Ali-Shtayeh and Jamous, R. (2002b): “Red List of Threatened Plants” of the West Bank and Gaza Strip and the Role of Botanical Gardens in their Conservation. Biodiversity and Environmental Sciences Studies Series No.(2).Biodiversity &Environmental Research Center (BERC), Til, Nablus, Palestine.(in Arabic)
- Ali-Shtayeh, M, Jamous, R. ,and Hamad, A, (2003): Guide to Trees and Shrubs from Palestine .Biodiversity &Environmental Research Center (BERC), Til , Nablus, Palestine.(in Arabic)
- Ali-Shtayeh, M and Jamous, R. (2006): **Ethno botany**: Ethno botany of Palestinian herbal medicine in the Northern West Bank and Gaza Strip: Review and comprehensive field study. Biodiversity and Environmental Sciences Studies Series No. (4). Biodiversity &Environmental Research Center (BERC), Til , Nablus, Palestine.(in Arabic)
- Alon, A, 1993. Wild flowers in rainbow colors. Tel Aviv: Society for protection of Nature in Israel (SPNI)
- Altieri, M. and Nicholls, C. (1999). Biodiversity, Ecosystem Function. And Insect Pest Management in Agricultural Systems. in: Collins, W. and Qualset, C. (Eds). Biodiversity in Agro ecosystems (pp 69-84).CRC press LLC, Washington, and D.C, USA.
- Applied Research Institute of Jerusalem (ARIJ), 1996. Environmental profile for the West Bank: Jenin District, Bethlehem. Palestine: Author.
- Applied Research Institute of Jerusalem (ARIJ), 1997.The Status of the Environment in the West Bank, Bethlehem. Palestine: Author.
- Al-Sheikh, B, Salman, M, Masalha,J, Salem,K, Ron,M, and Shmida,A. (2000).Preliminary Checklist and Ecological Data-Base of Plants of the West Bank .Al-Quds University, Faculty of Science and Technology, Department of Life Science, Abu Deis, West Bank.
- Atrash, I. (2003).Wildlife Field Guide of Wadi Gaza .Palestine Wilde Life Society .Beit Sahour, Palestine.
- Braighith, A. (1995). Forest and Woodland in Palestine from 1950 to 1995. Palestinian Ministry of Agriculture.
- Briefs prepared by the biological Survey of Canada (Terrestrial Arthropods). 1994. Terrestrial Arthropod Biodiversity: Planning a study and Recommended Sampling Techniques. www.biology.ualberta.ca/bsc/English.htm.
- Buntin, G; and Boonton, J., (1996): Alfalfa weevil (Coleoptera: Curculionidae) management in alfalfa by spring grazing with cattle. Journal of Economic Entomology 89(6):1631-1637.(1996)
- Buntin, G; and Boonton, J., (1997): Aphid (Homoptera: Aphididae) Management in alfalfa by spring grazing cattle. Journal of Entomological Science 32(3):332-342.(1997)

- Byers, R., Baker, G., Davidson, R., Hoebeke, E; and Sanderson, M , (2000): Richness and abundance of Carabidae and Staphylinidae (Coleoptera), in northeastern dairy pastures under intensive grazing .Great Lakes Entomologist 33(2):81-105.(2000)
- California Agriculture, Volume 49, Number 6, November-December (1995).
- California Biodiversity Council (CBC). (2000). Bioregions & Biodiversity. California homepage. http://ceres.ca.gov/biodiv/biodiversity/biodiv_def2.html.
- Dagher, S, (2006): Biodiversity and its Role in Agricultural Sector .in: Abu Ali, O et al (Eds) The Guide in Palestinian Food Security (pp 105-113).PHG,MA'AN Development Center, Palestine.(in Arabic)
- Dennis, P, (2003): Sensitivity of upland arthropod diversity to livestock grazing, vegetation structure and landform Food, Agriculture & Environment Vol.1(2):301-307.2003
- Dennis, P .et al, (2004): Consequences for biodiversity of reducing inputs to upland temperate pastures: Effects on beetles (Coleoptera) of cessation of nitrogen fertilizer application and reduction in stocking rates of sheep. Grass and Forage Science 59(2):121-135.(2004)
- Department of Agriculture, (2007).Metrological Data File. Jenin, West Bank.
- Department of the Environment, Sport and Territories (DEST), 1993.Biodiversity and its value, Biodiversity Series, paper no 1. DEST, Commonwealth of Australia.
- Dorrough, J., Moxham, C., Turner, V., and Sutter, G., (2006): Soil phosphorous and tree cover modify the effect of livestock grazing on plant species richness in Australian Woodland. Biological Conservation 130 (2006)394-405 journal homepage www.elsevier.com/locate/biocon
- Dowdy, A.; Berberet, R.; Stritzke, J.; Caddle, J.; and Mcnew, R., (1992): Late fall harvest, winter grazing, and weed control for reduction of alfalfa weevil (Coleoptera: Curculionidae) populations .Journal of Economic Entomology 85(5):1946-1953. (1992)
- Gibson, C., Hambler, C., and Brown, V, (1992): changes in spider araneae assemblages in relation to succession and grazing management. Journal of Applied Ecology 29(1) :132-142.(1992)
- Hawksworth, D. and Ritchie, J, (1993). Biodiversity and Biosystematics Priorities: Microorganisms and Invertebrates. CAB INTERNATIONAL, UK.
- Heimler, C., Neal.C. (1986): principles of SCIENCE book one. MERRILL publishing company, Columbus, Ohio.
- Heimler, C. and, Daniel, L., (1987): focus on Life Science. MERRILL publishing company, Columbus, Ohio.
- Helou, J. and Al-Qatan, O. (1997). Flowers of Palestine. Al-Qatan Charitable Trust, the Balkerne Press, Colchester, England.
- Hewitt, G., (1998): Grazing management as a means of regulating Spittle bug (Homoptera: Cercopidae) numbers in Central Brazil. Persquisa Agropecaria Brasilleira 23(7):697-708.(1998)
- Hrimat, N., Isaac, J., Abu-Amereyh, M., Ghatas, R., and Mhesen, F., (2002): The Agricultural Plant History of Palestine. Applied Research Institute-Jerusalem, Bethlehem, Palestine.(in Arabic)
- Isaac, J., Wolf, H., and Quba'a, K, (2005): The National Policy and Legislation for Promoting the Conservation of Agro-biodiversity in the Palestinian Authority .Ministry of Agriculture, PNA.

- Kharoob, J. (1992). Famous Birds of Palestine. Ecological Awareness Studies Series, Part 6. French Fathers Press. Jerusalem.
- Kim, K., and Weaver, R., (1994): Biodiversity and humanity: paradox and challenge .in: Kim, K, and, Weaver, R. (Eds). BIODIVERSITY and LANDSCAPES A paradox of humanity (PP 3-27).Cambridge university press, USA.
- Kirkwood, M.; Shapiro, L.; and Walker, X., (2000): Edaphic prairie arthropods with the exception of Diptera, shows no reaction to seasonal burns. Grinnell College Tillers 2,47-57 .(2000)
- Madeley, J. and Warnouck, K. (1995). BIODIVERSITY: A mater of Extinction, the challenge of protecting south's biological heritage, panos Media Briefing, No. 17 November 1995, Switzerland.
- Meinert, G.(1993).**Unkräuter Ungräser im Ackerbau** Eine Bestimmungshilfe , Ministerium für Ländlichen Raum,Ernährung Landwirtschaft und Forsten. Barden-Württemberg, Stuttgart, Germany.
- Mimris.org. (n.d). Az-Zababdeh Station Meteorological Data.
- Ministry of Agriculture and United Nations Development Program, (2003): Conservation and Sustainable Use of Dry Land Agro biodiversity in the Palestinian Authority. Socio-Economic Study in Hebron & Jenin Ramallah, PNA.
- Ministry of Environment, lands and Parks. 1998. Standards for components of British Colombia's Biodiversity. *Inventory Methods for Terrestrial Arthropods*.
- Mohammad, A., (2005): Rangeland Conditions at South West Bank .Hebron University Journal, Volume 2/No.1-2005, Hebron, Palestine.
- Moldenke, A., (n.d): Arthropods Ch.7 in: Soil Biology. http://soils.usda.gov/sqi/concepts/soil_biology/arthropods.html.
- Morita, H, (1997). HANDBOOK OF ARABLE WEEDS IN JAPAN, for correct identification, Kumiai Chemical Industry Co., Ltd. Nimura Printing Co., Ltd, Tokyo, Japan.
- National Biodiversity Strategy and Action Plan for Palestine, (1999).Palestinian Environmental Authority (PEnA), Hebron, Palestine.
- Oliver, I., Pearce, S., Greenslade, P., Penelope, J, and Bitton, D, (2006): Contribution of paddock trees to the conservation of terrestrial invertebrate biodiversity within grazed native pastures. Austral Ecology 31(1):1-12 .(2006)
- Orenstein, (n .d): Conservation in Israel, incredible potential, Enormous challenges (1).Center for Environmental Studies, Brown University. Http://www.jgenisrael.org/2rs_id=214.
- Palestinian Central Bureau of Statistics, (2006).Agricultural Statistics 2004/2005, Ramallah, Palestine.
- Perovolotsky, A., (1994): Conservation, Reclamation and Grazing in the Northern Negev: Contradictory or Complementary Concepts. Pastoral Development Network series 38.
- Poyry, J.; Lindgren, S.; Salminen, J.; and Kuussaari, M., (2004):Restoration of butterfly and moth communities in semi-natural grasslands by cattle grazing .Ecological Applications 14(6) 1656-1670 .(2004)
- Pyke, D., (1999): Interactions of Cattle Grazing and Climate on Semi-arid Ecosystem Function.http://www.nrel.colostate.edu/projects/brd_global_change/proj_62_cattle_grazing.html.

- Reid, A.(2006).Effect of fertilizer and grazing on grassland invertebrates PhD Dissertation, School of Biological Science, The University of Sydney, NSW, Australia .<http://www.eeob.iastate.edu/faculty/BronikoA/adelphdabstract.pdf>.
- Saarinen,K.;Jantunen, J.; and Valtonen, A.,(2005): Resumed Forest grazing restored a population of Euphydryas Aurinia (Lepidoptera: Nymphdidae) in SE Finland .European Journal of Entomology 102(4):683-690.(2005)
- Sawalha, K. (2005). Plant Biodiversity, study and analysis. Al-Quds University, Faculty of Science and Technology, Department of Life Science, Abu Deis, West Bank.
- Scudder. 1994. Pitfall Trapping. Department of Zoology, University of British Columbia, Vancouver, British Columbia, Canada V6T 1Z4. <http://www.emanrese.ca/eman/ecotools/protocols/terrestrial/arthropods/pitfall.html>
- Shugarat, H., (1998): Terrestrial ecosystems in changing environments CAMBRIDGE University press.
- Solbrig, O, (1994): Biodiversity: An introduction. in: O .Solbrig, H .Emden, and P.van Oordt (Eds).Biodiversity and Global Change (pp 13-20).CAB INTERNATIONAL, UK.
- SPSS Inc. (1999): SPSS 10 FOR WINDOWS - Statistical package for the social Sciences. Chicago, USA. <http://www.spss.com>.
- Steffan,D.; and Leschke, K,(2003): Effects of habitat management on vegetation and above-ground nesting bees and wasps of orchard meadows in central Europe .Biodiversity and Conservation 12(9):1953-1968.(2003)
- Sternberg, M., Gutman, M., Perovolotsky, A., Ungar, E., and Kigel, J., (2000): Vegetation response to grazing management in Mediterranean herbaceous community: a functional group approach. Journal of Applied Ecology 2000, 37,224-237.
- Toman, J. and Felix, J. (1974).A Field Guide in Color to PLANTS AND ANIMALS .Octopus Books Limited, London.
- United Nations–Treaty Series.1993.Multilateral ‘Conservation on biological diversity (with annexes) concluded at Rio de Janeiro on 5 June 1992.Volume 1760I30619.
- Varies, M.; Tallwin, J.; Dulphy, J.; Sayer, M.; and Diana, E, (2004): Effects of livestock breed and stocking rate on sustainable grazing systems: Short-term effect on fauna. in: land use systems in grassland dominated regions: proceedings of the 20th General Meeting of European Grassland Federation. (Held 21 June2004-24 June 2004 at Luzern, Switzerland); pp 626-628 (2004)
- Varies, M.; Tallwin, J.; Dulphy, J.; Sayer, M.; and Diana, E., (2005): Effects of livestock breed and stocking rate on sustainable grazing systems: Butterfly diversity and abundance .in: integrated efficient grassland farming and biodiversity: proceedings of the 12th international occasional symposium of European Grassland Federation. (Held 29 Aug 2005-31 Aug 2005 at Tartu, Estonia);pp 227230.(2005)
- Watkinson, A., Ormerod, S., (2001): Grasslands, Grazing and Biodiversity: editor’s introduction. Journal of applied ecology 2001, 38:233-237.
- William, G. and Marcos, (1994).The Quantitative Basis of Pest Management: Sampling and Measuring. in: Robert and William (Eds). Introduction to Insect Pest Management <http://www.animalethics.org>

Appendix 4.1: Different plant species of trees and shrubs present in Mirkeh sampling area.

Family Name	Common Name	Scientific Name
Anacardiaceae	Atlantic Pistachio	<i>Pistatia atlantica Desf</i>
	Mastic Tree	<i>Pistacia lentiscus</i>
	Palestinian Pistachio	<i>Pistacia palestina Boiss</i>
	Sumach	<i>Rhus coriaria</i>
Cactaceae	Prickly Pear	<i>Opuntia ficus indica(Mill)</i>
Caesalpinaceae	Carob	<i>Ceratonia siliqua (L)</i>
Caparidaceae	Caper	<i>Capparis spinosa(L)</i>
Compositae	Elecampane	<i>Inula viscosa(L)</i>
Cupressaceae	Italian Cypress	<i>Cupressus sempervirens</i>
Leguminosae	Thorny Broom	<i>Calyctome villosa</i>
Liliaceae	Ajram	<i>Ruscus aculatus</i>
Moraceae	Common Fig Tree	<i>Ficus carica (L)</i>
Oleaceae	Olive	<i>Olea europea (L)</i>
Pinaceae	Aleppo or Jerusalem Pine	<i>Pinus halepensis Mill</i>
	Brutian Pine	<i>Pinus brutia Ten</i>
Rhamnaceae	Palestinian Buckthorn	<i>Rhamanus palestinus Boss</i>
	Syrian christi-Thorn	<i>Ziziphus spina-christi(L)</i>
Rosaceae	Almond	<i>Amygdalus communis(L)</i>
	Burnet	<i>Sarcopoterium spinosum</i>
	Spiny Hawthorn	<i>Crataegus aronia (L)</i>
	Syrian Pear	<i>Pyrus syriaca Boiss</i>
Rutaceae	African Rue	<i>Ruta chalepensis L</i>
Styracaceae	Storax Tree	<i>Styrax officinalis (L)</i>

Appendix 4.2: Different herbaceous plant species present in Mirkeh sampling site.

Family Name	Common Name	Scientific Name
Amaryllidaceae	Daffodil	<i>Narcissus Spp</i>
Araceae	Arum	<i>Arum palaestinum</i>
Boraginaceae	Bugloss	<i>Anchus italic (Retz)</i>
Caryophyllaceae	Silvery White Wart	<i>Paronychia argentea</i>
Chenopodiaceae	Shuhimeh	<i>Salsola schweeinfurthii</i>
Compositae	Elecampane	<i>Inula viscosa(L)</i>
	خرقيش حمير	<i>Notobasis syriaca</i>
	Holy Thistle	<i>Silybum marianum</i>
	Thistle	<i>Tyrimnus leucographus)</i>
	Wild Chamomile	<i>Matricaria chamomile</i>
		<i>Matricaria inodora L</i>
	سنارية	<i>Scolymus maculatus</i>
	Shrubby centaury	<i>Cntaurea hyalolepis</i>
Cruciferae	Black mustard	<i>Brasica nigra</i>
		<i>Erucaria hispanica</i>
	Charlock	<i>Sinapis arvensis</i>
Cucurbitaceae	Bitter Apple	<i>Citrullus colocynthis</i>
	Squirting Cucumber	<i>Ecaballium elaterium</i>
Dipsaceae	Palestine Scabios	<i>Pterocephalus palaestinus</i>
Gramineae	Aegilops	<i>Aegilops buncialis Vis</i>
	Johnson grass	<i>Sorghum halepensis Pers</i>
	Wild Barley	<i>Hordium bulbosum L</i>
	Wild Oat	<i>Avena sterilis</i>
	Wild Oat	<i>Avena fatua</i>
		<i>Phalaris brachistachys</i>
		<i>Phalaris minor</i>

		<i>Phalaris paradoxa</i>
	Ryegrass	<i>Lolium rigidum</i>
	Bermuda grass	<i>Cynodon dactylon</i>
Iridaceae	Dwarf Iris	<i>Iris reticulata</i>
	Sword-Flag	<i>Gladiolus aleppicus Boiss</i>
Labiatae	Common Sage	<i>Salvia fruticosa Mill</i>
	Palestine Sage	<i>Salvia palestina</i>
	Syrian Sage	<i>Salvia syriaca</i>
	Thyme	<i>Thymus bovei</i>
	Wild Thyme	<i>Majorana syriaca</i>
	Zaytman	<i>Thymbra spicta</i>
	Cat thyme	<i>Teucrium polium</i>
Leguminosae	Locust Pods	<i>Prosopis farcta</i>
Liliaceae	Medicinal Squill	<i>Urginea maritima</i>
Linaceae	Wild Flax	<i>Linium pubescens (Russel)</i>
Malvaceae	Least Mallow	<i>Malva parviflora</i>
	Hollyhock	<i>Alcea setosa</i>
Papilionaceae	Egyptian clover	<i>Trifolium alexandrium</i>
		<i>Trifolium pilulare</i>
		<i>Trifolium tomentosum</i>
		<i>Trifolium spumosum</i>
		<i>Trifolium resupinatum</i>
		<i>Trifolium lappaceum</i>
	Purple clover	<i>Trifolium purporeum</i>
		<i>Trifolium campestre</i>
	Blue Lupine	<i>Lupin pilosus (L)</i>
	Wild Pea	<i>Pisum fulvum (Smith)</i>
	Wild Pea	<i>Pisum elatius</i>

		<i>Tetragonoiliobus palaestinus</i>
	Milk Vetch	<i>Astragalus tuberosus</i> (DC)
	Vetch	<i>Vicia hirsuta</i> L
	Vetch	<i>Vicia tetrasperma</i>
	Vetch	<i>Vicia vilosa</i>
Plantaginaceae	Ribwort plantaine	<i>Plantago lanceolata</i>
	plantaine	<i>Plantago asiatica</i> L
Primulacea	Persian Cyclamen	<i>Cyclamen persicum</i>
Ranunculaceae	Anemone	<i>Anemone coronaria</i> (L)
	Pheasant's Eye	<i>Adonis aestivalis</i> (L)
Umberelliferae	Fennel	<i>Foeniculum vulgare</i>
Urticaceae	Roman Nettle	<i>Urtica pilulifera</i>
		<i>Urtica urens</i> L

Appendix 4.3: Different key bird species present in Mirkeh sampling area.

Family Name	Common Name	Scientific Name
Accipitridae	Black Kite	<i>Milvus migrans</i>
	Honey Buzzard	<i>Pernis apivorus</i>
	Lesser-spotted Eagle	<i>Aquila pomarina</i>
	Sparrow -hawk	<i>Accipitser ninsus</i>
Alaudidae	Crested Lark	<i>Galerida cristata</i>
	Sky Lark	<i>Alauda arvensis</i>
Ardeidae	Cattle Egret	<i>Bubulcus ibis</i>
Burhinidae	Stone Curlew	<i>Burhinus oedicnemus</i>
Charadriidae	Lapwing	<i>Vanellus vanellus</i>
Ciconiidae	White Stork	<i>Ciconia ciconia</i>
Columbidae	Collared Dove	<i>Streptopelia decaocto</i>
	Laughing Dove	<i>Streptopelia senegalensis</i>
Corvidae	Hooded Crow	<i>Corvus corone</i>

	Jay	<i>Garulus glandarius</i>
	Raven	<i>Corvux corax</i>
Falconidae	Kestrel	<i>Falco tinnunculus</i>
Fringillidae	Chaffinch	<i>Fringilla coelebs</i>
	Gold finch	<i>Carduelis carduelis</i>
	Green finch	<i>Carduelis chloris</i>
Hirandinadae	Common Swallow	<i>Hirundo rustica</i>
Laniidae	Great Shrike	<i>Lanius excubitor</i>
	Wood chat Shrike	<i>Lanius senator</i>
Meropidae	Bee-eater	<i>Merops apiaster</i>
Motacilladae	White Wagtail	<i>Motacillo alba</i>
Nectariniidae	Palestine Sunbird	<i>Nectarinis osea</i>
Paridae	Great Tit	<i>Parus major</i>
Passeridae	House Sparrow	<i>Passer domestica</i>
	Spanish Sparrow	<i>Passer hispaniolensis</i>
Phasianidae	Chukar	<i>Alectoris chukar</i>
	Quail	<i>Coturnix coturnix</i>
Picidae	Syrian Woodpecker	<i>Dendrocopos syriacus</i>
Pyconotidae	Common Bulbul	<i>Pycononotus xanthopygos</i>
Strigidae	Little Owl	<i>Athene noctua</i>
	Long –eared Owl	<i>Asio otus</i>
Sylviidae	Black Cap	<i>Sylvia atricapilla</i>
	Chiffchaff	<i>Phylloscopus collybita</i>
	Garden Warbler	<i>Sylvia borin</i>
	Graceful Warbler	<i>Prinia gracilis</i>
	Olivaceous Warbler	<i>Hippolias pallida</i>
	White Throat Warbler	<i>Sylvia communis</i>
Turdidae	Black Red Start	<i>Phoenicarus ochruros</i>

	European Blackbird	<i>Turdus merula</i>
	Robin	<i>Erithacus rubecula</i>
	Stone Chat	<i>Saxicola torquata</i>
Tytonidae	Barn Owl	<i>Tyto alba</i>
Upupidae	Hoopoe	<i>Upupa epops</i>

Appendix 4.4: Threatened and rare plants present in Mirkeh sampling area (*= Ali-shtayeh and Jamous, 2002b, ** = Al-Sheikh, Masalha, Salem, Salman, Ron and Shmida, 2000).

Family Name	Common Name	Scientific Name	Rarity
Anacardiaceae	Atlantic Pistachio	<i>Pistatia atlantica Desf</i>	RP *
	Mastic Tree	<i>Pistacia lentiscus</i>	RP *
	Palestinian Pistachio	<i>Pistacia palestina Boiss</i>	RP*
	Sumach	<i>Rhus coriaria</i>	R *
Compositae	Wild Chamomile	<i>Matricaria chamomile</i>	RR **
Cupressaceae	Italian Cypress	<i>Cupressus sempervirens</i>	RR *
Labiatae	Palestine Sage	<i>Salvia palestina</i>	RP *
	Sage	<i>Salvia mukticaulis</i>	RR*
	Syrian Sage	<i>Salvia syriaca</i>	RP *
	Thyme	<i>Thymus bovei</i>	RR *
Leguminosae	Locust Pods	<i>Prosopis farcta</i>	RP *
Liliaceae	Ajram	<i>Ruscus aculatus</i>	R **
Malvaceae	Hollyhock	<i>Alcea digitaria</i>	RR **
Moraceae	Common Fig Tree	<i>Ficus carica (L)</i>	R *
Papilionaceae	Egyptian clover	<i>Trifolium alexandrium</i>	R**
	Blue Lupine	<i>Lupin pilosus (L)</i>	R **
	Wild Pea	<i>Pisum elatius</i>	R **
	Vetch	<i>Vicia vilosa</i>	RR **
Pinaceae	Aleppo Pine	<i>Pinus halepensis Mill</i>	RP *

	Brutian Pine	<i>Pinus brutia Ten</i>	RP *
Ranunculaceae	Pheasant's Eye	<i>Adonis aestivalis (L)</i>	RR *
Rhamnaceae	Syrian christi-Thorn	<i>Ziziphus spina-christi(L)</i>	RP *
Rosaceae	Syrian Pear	<i>Pyrus syriaca Boiss</i>	RP *

RR =Very Rare, **R** = Rare and **RP** =Potentially Rare.

Appendix 4.5: Threatened and rare birds present in Mirkeh sampling area (1 = Ali-shtayeh and Hammad, 1995, 2 = Atrash, 2003, 3=ARIJ, 1997).

Family Name	Common Name	Scientific Name	Rarity
Accipitridae	Black Kite	<i>Milvus migrans</i>	R 1,R 3
	Egyptian Vulture	<i>Neophron perconopterus</i>	R 1,R 3
Falconidae	Kestrel	<i>Falco tinnunculus</i>	R 1
Fringillidae	Gold finch	<i>Carduelis carduelis</i>	E 2
Hirandinadae	Common Swallow	<i>Hirundo rustica</i>	RP 1
Meropidae	Bee-eater	<i>Merops apiaster</i>	RP 1
Phasianidae	Chukar	<i>Alectoris chukar</i>	RP 2
	Sand Partridge	<i>Ammoperdix heqi</i>	RP 2
Sylviidae	White Throat Warbler	<i>Sylvia communis</i>	RP 1

R = Rare, **RP** =Potentially Rare and **E**=Extinct.

Appendix 4.6.1: Number of arthropods collected in treatment 1 during the four seasons.

Season	Rep.	Beetles	Ants	Total Insects	Spiders	Non- Insect Arthropods	Total Arthropods
Summer	R 1	9	160	194	25	55	274
	R 2	23	251	283	28	74	385
	R3	13	119	153	15	20	188
Total		45	530	630	68	149	847
Autumn	R 1	206	361	598	7	29	634
	R 2	340	206	559	19	64	642
	R3	340	145	581	10	32	623
Total		958	712	1738	36	125	1899
Winter	R 1	29	7	63	23	28	114

	R 2	46	19	83	22	43	148
	R3	45	1	70	30	37	137
Total		120	27	216	75	108	399
Spring	R 1	18	7	35	37	41	113
	R 2	49	34	95	26	36	157
	R3	33	70	109	27	29	165
Total		100	111	239	90	106	435

Appendix 4.6.2: Number of arthropods collected in treatment 2 during the four seasons.

Season	Rep.	Beetles	Ants	Total Insects	Spiders	Non- Insect Arthropods	Total Arthropods
Summer	R 1	21	114	152	16	69	237
	R 2	16	83	103	16	36	155
	R3	7	169	191	11	38	240
Total		44	366	446	43	143	632
Autumn	R 1	155	28	196	7	90	293
	R 2	224	54	292	12	91	395
	R3	244	1	274	8	64	346
Total		623	83	762	27	245	1034
Winter	R 1	43	63	112	16	34	162
	R 2	31	7	40	9	19	68
	R3	50	11	67	12	38	117
Total		124	81	219	37	91	347
Spring	R 1	32	54	88	11	22	121
	R 2	32	30	64	7	22	93
	R3	58	19	88	18	30	136
Total		122	103	240	36	74	350

Appendix 4.7: Results of statistical analysis

Crosstabs:Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Treatment * Beetles	24	100.0%	0	.0%	24	100.0%
Treatment * Ants	24	100.0%	0	.0%	24	100.0%
Treatment * Total Insects	24	100.0%	0	.0%	24	100.0%
Treatment * Spiders	24	100.0%	0	.0%	24	100.0%
Treatment * Non-Insect Arthropods	24	100.0%	0	.0%	24	100.0%
Treatment * Total Arthropods	24	100.0%	0	.0%	24	100.0%

Treatment * Beetles

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	24.000	21	.293
Likelihood Ratio	33.271	21	.043
Linear-by-Linear Association	.216	1	.642
N of Valid Cases	24		

a 44 cells (100.0%) have expected count less than 5. The minimum expected count is .50.

Treatment * Ants: Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	17.333	18	.500
Likelihood Ratio	23.907	18	.158
Linear-by-Linear Association	2.747	1	.097
N of Valid Cases	24		

38 cells (100.0%) have expected count less than 5. The minimum expected count is .50.

Treatment * Total Insects: Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	24.000	22	.347
Likelihood Ratio	33.271	22	.058
Linear-by-Linear Association	1.959	1	.162
N of Valid Cases	24		

46 cells (100.0%) have expected count less than 5. The minimum expected count is .50.

Treatment * Spiders: Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	21.333	17	.212
Likelihood Ratio	29.452	17	.031
Linear-by-Linear Association	9.372	1	.002
N of Valid Cases	24		

a 36 cells (100.0%) have expected count less than 5. The minimum expected count is .50.

Treatment * Non-Insect Arthropods: Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	20.000	18	.333
Likelihood Ratio	27.726	18	.066
Linear-by-Linear Association	.392	1	.531
N of Valid Cases	24		

a 38 cells (100.0%) have expected count less than 5. The minimum expected count is .50.

Treatment * Total Arthropods: Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	24.000	23	.404
Likelihood Ratio	33.271	23	.076
Linear-by-Linear Association	2.047	1	.152
N of Valid Cases	24		

a 48 cells (100.0%) have expected count less than 5. The minimum expected count is .50.

Oneway: Descriptives

		N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Beetles	Summer	6	14.83	6.40	2.61	7	23
	Autumn	6	251.50	74.65	30.47	155	340
	Winter	6	40.67	8.59	3.51	29	50
	Spring	6	37.00	14.23	5.81	18	58
	Total	24	86.00	104.45	21.32	7	340
Ants	Summer	6	149.33	59.00	24.09	83	251
	Autumn	6	132.50	135.75	55.42	1	361
	Winter	6	18.00	22.83	9.32	1	63
	Spring	6	35.67	23.02	9.40	7	70
	Total	24	83.88	92.00	18.78	1	361
Total Insects	Summer	6	179.33	60.61	24.74	103	283
	Autumn	6	416.67	181.51	74.10	196	598
	Winter	6	72.50	23.89	9.75	40	112
	Spring	6	79.83	26.36	10.76	35	109

	Total	24	187.08	168.60	34.42	35	598
Spiders	Summer	6	18.50	6.53	2.67	11	28
	Autumn	6	10.50	4.59	1.88	7	19
	Winter	6	18.67	7.79	3.18	9	30
	Spring	6	21.00	11.15	4.55	7	37
	Total	24	17.17	8.40	1.71	7	37
Non-Insect Arthropods	Summer	6	48.67	20.93	8.55	20	74
	Autumn	6	61.67	26.91	10.99	29	91
	Winter	6	33.17	8.52	3.48	19	43
	Spring	6	30.00	7.56	3.09	22	41
	Total	24	43.38	21.20	4.33	19	91
Total Arthropods	Summer	6	246.50	79.83	32.59	155	385
	Autumn	6	488.83	161.30	65.85	293	642
	Winter	6	124.33	33.09	13.51	68	162
	Spring	6	130.83	27.29	11.14	93	165
	Total	24	247.63	173.62	35.44	68	642

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Beetles	Between Groups	221466.333	3	73822.111	50.141	.000
	Within Groups	29445.667	20	1472.283		
	Total	250912.000	23			
Ants	Between Groups	79876.458	3	26625.486	4.638	.013
	Within Groups	114806.167	20	5740.308		
	Total	194682.625	23			
Total Insects	Between Groups	464402.833	3	154800.944	16.344	.000
	Within Groups	189429.000	20	9471.450		
	Total	653831.833	23			
Spiders	Between Groups	379.000	3	126.333	2.031	.142
	Within Groups	1244.333	20	62.217		
	Total	1623.333	23			
Non-Insect Arthropods	Between Groups	3874.125	3	1291.375	3.997	.022
	Within Groups	6461.500	20	323.075		
	Total	10335.625	23			
Total Arthropods	Between Groups	522143.125	3	174047.708	20.338	.000
	Within Groups	171154.500	20	8557.725		
	Total	693297.625	23			

Post Hoc Tests

Multiple Comparisons: LSD

Dependent Variable	(I) Season	(J) Season	Mean Difference (I-J)	Std. Error	Sig.
Beetles	Summer	Autumn	-236.67	22.153	.000
		Winter	-25.83	22.153	.257

		Spring	-22.17	22.153	.329
	Autumn	Summer	236.67	22.153	.000
		Winter	210.83	22.153	.000
		Spring	214.50	22.153	.000
	Winter	Summer	25.83	22.153	.257
		Autumn	-210.83	22.153	.000
		Spring	3.67	22.153	.870
	Spring	Summer	22.17	22.153	.329
		Autumn	-214.50	22.153	.000
		Winter	-3.67	22.153	.870
Ants	Summer	Autumn	16.83	43.743	.704
		Winter	131.33	43.743	.007
		Spring	113.67	43.743	.017
	Autumn	Summer	-16.83	43.743	.704
		Winter	114.50	43.743	.016
		Spring	96.83	43.743	.039
	Winter	Summer	-131.33	43.743	.007
		Autumn	-114.50	43.743	.016
		Spring	-17.67	43.743	.691
	Spring	Summer	-113.67	43.743	.017
		Autumn	-96.83	43.743	.039
		Winter	17.67	43.743	.691
Total Insects	Summer	Autumn	-237.33	56.189	.000
		Winter	106.83	56.189	.072
		Spring	99.50	56.189	.092
	Autumn	Summer	237.33	56.189	.000
		Winter	344.17	56.189	.000
		Spring	336.83	56.189	.000
	Winter	Summer	-106.83	56.189	.072
		Autumn	-344.17	56.189	.000
		Spring	-7.33	56.189	.897
	Spring	Summer	-99.50	56.189	.092
		Autumn	-336.83	56.189	.000
		Winter	7.33	56.189	.897
Spiders	Summer	Autumn	8.00	4.554	.094
		Winter	-.17	4.554	.971
		Spring	-2.50	4.554	.589
	Autumn	Summer	-8.00	4.554	.094
		Winter	-8.17	4.554	.088
		Spring	-10.50	4.554	.032
	Winter	Summer	.17	4.554	.971
		Autumn	8.17	4.554	.088
		Spring	-2.33	4.554	.614
	Spring	Summer	2.50	4.554	.589
		Autumn	10.50	4.554	.032
		Winter	2.33	4.554	.614
Non-Insect Arthropods	Summer	Autumn	-13.00	10.377	.225
		Winter	15.50	10.377	.151
		Spring	18.67	10.377	.087
	Autumn	Summer	13.00	10.377	.225

		Winter	28.50	10.377	.012
		Spring	31.67	10.377	.006
	Winter	Summer	-15.50	10.377	.151
		Autumn	-28.50	10.377	.012
		Spring	3.17	10.377	.763
	Spring	Summer	-18.67	10.377	.087
		Autumn	-31.67	10.377	.006
		Winter	-3.17	10.377	.763
Total Arthropods	Summer	Autumn	-242.33	53.410	.000
		Winter	122.17	53.410	.033
		Spring	115.67	53.410	.043
	Autumn	Summer	242.33	53.410	.000
		Winter	364.50	53.410	.000
		Spring	358.00	53.410	.000
	Winter	Summer	-122.17	53.410	.033
		Autumn	-364.50	53.410	.000
		Spring	-6.50	53.410	.904
	Spring	Summer	-115.67	53.410	.043
		Autumn	-358.00	53.410	.000
		Winter	6.50	53.410	.904

*The mean difference is significant at the .05 level.