Diversity and *In-Situ* Conservation of Legume Species in the Mediterranean Ecosystem

M. Ajlouni[1]*, A. El-Oqlah[2], Abdul Latief A. Al-Ghzawi[3], A.M. Al-Tawaha[4] and Ahmed Amri[5]

ABSTRACT

To study the legume diversity in the north part of Jordan, three sites (Baoun, Samta and Rayyan) were selected in Ajloun area. The botanical survey was conducted over four successive spring seasons between the years 2000 and 2004. Our results indicated that the total number of species identified varied between sites, with the highest numbers of species recorded in Samta and Rayyan sites. The predominant species in the three sites were *Lathyrus cicera* and *Trifolium tomentosum*. Shannon-weiver diversity index values ranged from 1.75 to 2.46 for the sites. Baoun site showed the highest diversity index value. This study indicated that Ajloun mountainous areas have biodiversity -rich ecosystems wich require concurrent and substential efforts for *ex situ* and *in situ* conservation of species of global importance.

Keywords: Legume, Genetic diversity, Mediterranean ecosystem, Jordan.

INTRODUCTION

Biological diversity embraces the total variability of all living organisms and the ecological complexes they inhabit (IPGRI, 1999). Clearly, higher diversity means not only a higher number of possible energy pathways, and therefore more opportunities for adjustments and adaptations, but also more variable stock of genetic information, which may be useful for the evolution of particular species and therefore of the ecosystem as a whole (Krivtsov et al., 2000). Agricultural biodiversity or agro-biodiversity occupies a unique place within the biological diversity and is essential to satisfy basic human needs for food and livelihood security (CBD, 2000). Agro-biodiversity is actively managed by farmers and contains: genetic resources for food and agriculture such as harvested crop varieties, livestock breeds, fish species, non-domesticated wild relatives, forests, rangelands and aquatic ecosystems, as well as components of agricultural biodiversity that provide ecological services such as non-harvested species within production ecosystems. It also includes components that support food provision such as pollinators, nutrient cycling species and natural enemies (CBD, 2000). This part of the biodiversity is the most valuable core for the food security of rural areas which depend on this part of the biodiversity for their food, medicines and animal feed.

Drylands are very important ecosystems covering over 6.1 billion hectares representing more than 41% of the total global land area and are inhabited by one-sixth of the world's population (CBD, 2000). Dryland areas include

1)Plant Production Department, Faculty of Agriculture, Jordan University of Science and Technology, Irbid, P. O. Box 3030, Irbid 22110, Jordan.

2) Department of Biological Sciences, Faculty of Science, Yarmouk University, Irbid, Jordan.

3)Department of Biology and Biotechnology, Faculty of Science, The Hashemite University, Zarqa, Jordan.

4)Department of Biological Sciences, Al Hussein Bin Talal University, Ma'an, P.O. Box 20,Jordan.

5) International Centre for Agricultural Research in the Dry Areas (ICARDA),P. O. Box 5466, Aleppo, Syria.

*E-mail: majl@just.edu.jo

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semi-arid regions with an annual rainfall below 600 mm, arid regions and hyper-arid regions. The biological diversity of drylands is very significant and valuable because of its high species' diversity and high endemism found within some biomes. The Mediterranean-type ecosystems are exceptionally important in this regard. They contain 4 out of the 18 hot spots of endemic flora and one of the three nuclear centers of agricultural origin defined by Hawkes (1983); the Near East region. This region is the center of origin for wheat, barley, lentils, forage species and many fruit trees and their wild relatives, which were identified as a target group for conservation 30 years ago. The species which originated from this area are feeding over 38 % of the world's population (UNDP, 2007). Wheat alone accounts for about one-third of the global food production.

Dryland ecosystems are fragile and subjected to many degradation factors such as introduction of exotic species, overexploitation of biological resources, habitat reduction by land use change, pastoral overgrazing, expansion of cultivation and other human activities (Korneck and Sukopp,1988; Kerr and Currie, 1995; Pimm et al., 1995; Tilman, 1999; Raffaello, 2001; Palomares, 2001). This degradation of habitats and the loss of related biodiversity are already leading to irreversible situations responsible for migration of local communities, desertification and increasing mass poverty (Meilleur and Hodgkin, 2004). Therefore, the global conservation community as well as we in Jordan are increasingly concerned with dryland biodiversity and the consequence of its conservation and management, especially because the largest part of Jordan is considerd as dryland and there is increasing concern of the negative effects of the loss of agrobiodiversity , expressed by local, national and global communities. Jordan, situated at the center of a unique biota, represents the biodiversity of drylands. It is among the few countries active in promoting the conservation of biodiversity. Unfortunately, plant diversity in Jordan as in the whole region has declined dramatically over the past two centuries. Many native Jordanian species have been lost, including some species that were once widespread and common. This decline is largely due to the massive increase in the population followed by land encroachment for agricultural and urban utilization, which reflected on natural resources (Al-Eisawi, 2003). Additional important factors affecting biodiversity include: deforestation, deterioration of rangelands by over-grazing, soil erosion, illegal collection of plants, as well as the depletion of the major water resources (Wiseman and Hopkins, 2000). Recently, however, Jordan has started taking major steps to conserve its biodiversity. Nowadays, more than a percentage of 4% of Jordan's land area is preserved within declared nature reserves. Yet, complete and extensive surveys and specific studies in Jordan have not been so far carried out and still more is needed to target the conservation of plants that are of global importance such as the wild progenitors of legume species. For the above reasons, the conservation of agrobiodiversity in Jordan was top priority on the Jordanian environmental agenda.

This research was part of a five-year regional project (1999-2004) funded by the Global Environment Facility (GEF) entitled "Conservation and Sustainable Use of Dryland Agrobiodiversity in Jordan, Lebanon, the Palestinian Authority and Syria". The project was coordinated at the regional level by the International Center for Agricultural Research in Dry Areas (ICARDA). It aimed at promoting the *in situ* or on-farm conservation and sustainable use of 16 targeted and globally important plant genera (Triticum, Aegilops, Hordeum, Lens, Allium, Medicago, Lathyrus, Vicia, Trifolium, Amygdalus, Pyrus, Prunus, Pistachia, Ficus, Olea and Cerasus). One of the target outputs of this project was to understand the current status of target species in these countries and to assess the threats that

could lead to their loss. The current study involved conducting botanical surveys in two target areas in Jordan with different ecosystems: a) Ajloun (the highlands); a mountainous region with dry sub-humid Mediterranean climate and b) Muwaqqar with an arid semi desert ecosystem. The objectives were:

(i) to assess the species richness in the two areas, with emphasis on legume species and (ii) to understand the relationship between species biodiversity and the conditions of the two ecosystems. This paper presents the results of the botanical survey for the three selected monitoring sites (Baoun, Samta and Rayyan) within Ajloun ecosystem.

MATERIALS AND METHODS

Sampling Methodology and Survey

The botanical survey was conducted over four successive spring seasons between the years 2000 and 2004 at three selected monitoring sites (Baoun, Samta and Rayyan) in Ajloun highlands. The main eco-geographical characteristics of the three sites are presented in Table 1.

Table 1: The main eco-geographic characteristics of the monitoring sites located in Ajloun in Jordan assessed in 2000.

Monitoring sites	Climate type	Average altitude (m)	Average rainfall (mm)	General physiography	Predominant habitat
Ba'oun	Mediterranean highland	576	500	Valley	Olive orchards
Samta	Mediterranean highland	1095	600	Upland	Natural grass, Dwarf shrubs
Rayyan	Mediterranean lowland	328	500	Valley	Olive orchards

In this survey, the transect-quadrat method was used. At each site, 6 transects, each 50 m long, were randomly chosen but with consideration given to the spatial heterogeneity of the site. On the right and left sides of each transect, 1 m² quadrats were marked alternatively every 10 m to have five quadrats per transect. The following parameters were recorded in each quadrat: species' richness, species' density and species' frequency. The species were identified using Flora Palestina (Zohary and Naomi, 1972). These samples were ultimately deposited in the herbarium of the Biology Department at Yarmouk University, Irbid, Jordan.

DATA ANALYSIS

Species Richness: total number of species occurring per unit area, e.g. 1 m² quadrat.

Plant Density (D): total individuals of each species occurring per unit area, e.g. 1 m² quadrat.

Frequency (F): number of quadrats where a species occurs as a percentage of the total number of quadrats analyzed.

Shannon-Weaver Diversity Index (H): measures plant diversity (the rarity/commonness of species in a community). The formula used to calculate this index was as follows (Pielou, 1975):

$$\text{Diversity } H = -\sum_{i=1}^{s} pi\, ln(pi)$$

where s : the number of species .

pi : the proportion of individuals or the abundance of the i^{th} species expressed as a proportion of the total cover.

ln: log with the base e.

Importance Value (IPVi): calculated from the formula:

IPVi = (RDi + RFi + RCi)/3;

where RDi (Relative Density): number of individuals of a given species (n) as a proportion of the total number of individuals of all species; RFi (Relative Frequency): the frequency of a given species as a proportion of the sum of the frequencies for all species; RCi (Relative Coverage): the proportion of the total coverage (TC) for all species, calculated as RCi = Ci/Ti = Ci/∑Ci; where Ci : is the sum of the coverage of all the species.

RESULTS AND DISCUSSION

Species' Richness and Distribution

The numbers of species at the three sites are presented in Tables 2, 3 and 4. In Baoun site, a total of 15 species were observed (Table 2). The dominant and co-dominant species were *T. tomentosum* (62 plant samples out of 235 found in the survey plot). followed by *Trigonella spinosa* (31 plants) and *L. cicera* (29 plants). On the other hand, *Astragalus cretaceus, Astragalus epiglottis, Lathyrus blepharicarpus, Lotus ornithopodiodes, Trifolium purpureum* and *Scorpiurus muricatus* were represented by less than five plant samples out of 235 found in the survey plot at Baoun site.

Table 2: Number of legumes plant species found at Baoun site in Ajloun area(2000-2004).

Species	Transect1	Transect2	Transect3	Transect4	Transect5	Transect6	Total
Astragalus cretaceus Boiss.et Ky	0	1	0	0	0	0	1
***Astragalus epiglottis* L.**	0	0	0	1	1	0	2
Lathyrus blepharicarpus Boiss.	1	0	0	0	2	0	3
***Lathyrus cicera* L.**	3	4	2	10	4	6	29
***Lotus ornithopodiodes.* L.**	0	0	0	0	2	0	2
***Lotus peregrinus* L.**	4	2	5	2	5	7	25
Medicago turbinata* L. *All.	4	1	1	3	0	0	9
Pisum syriacum (Berg.)Lehm	15	0	6	1	0	0	22
Trifolium clusii Godr. et Gren.	3	0	0	1	4	0	8
Trifolium purpureum Loisel.	1	0	0	1	0	1	3
***Trifolium tomentosum* L.**	12	18	8	11	10	3	62
Trigonella kotschyi Fenzl.ex Boiss.	1	0	13	0	0	0	14
***Trigonella spinosa* L.**	5	4	0	15	0	7	31
***Vicia peregrenia* L.**	0	8	0	9	5	0	22
***Scorpiurus muricatus* L.**	0	0	0	2	0	0	2

Table 3: Number of legumes plant species found at Samta site in Ajloun area (2000-2004).

Species	Transect1	Transect2	Transect3	Transect4	Transect5	Transect6	Total
Astragalus cretaceus Boiss. et Ky	4	2	0	12	1	8	27
***Astragalus epiglottis* L.**	0	5	0	6	0	3	14
Lathyrus blepharicarpus Boiss.	12	1	0	0	0	0	13
***Lathyrus cicera* L.**	43	33	81	1	24	24	206
***Lotus ornithopodiodes.* L.**	5	0	0	0	0	0	5
***Lotus peregrinus* L.**	0	0	0	0	2	0	2
***Medicago polymorpha* L.**	0	8	0	0	2	0	10
Medicago turbinata* L. *All.	0	1	0	0	0	0	1
Pisum syriacum Boiss.	2	1	1	0	0	1	5
***Scorpiurus muricatus* L.**	0	0	0	0	1	0	1
Trifolium clusii Godr. et Gren.	0	1	0	2	0	0	3
***Trifolium purpureum* L.**	9	6	0	1	0	0	16
***Trifolium tomentosum* L.**	92	0	4	3	4	10	113
Trigonella kotschyi Fenzl. ex Boiss.	15	1	0	1	2	38	57
Trigonella caelesyriaca Boiss.	0	0	0	0	1	0	1
***Trigonella spinosa* L.**	0	0	0	0	0	16	16
***Vicia peregrenia* L.**	0	0	0	0	0	3	3

Table 4: Number of legumes plant species found at Rayyan site in Ajloun area (2000-2004).

Species	Transect1	Transcet2	Transcet3	Transcet4	Transcet5	Transcet6	Total
Astragalus cretaceus Boiss. et Ky	0	0	0	6	1	5	12
***Astragalus epiglottis* L.**	0	0	0	0	0	8	08
Lathyrus blepharicarpus Boiss.	0	1	0	33	0	0	34
***Lathyrus cicera* L.**	25	22	18	36	12	32	145
***Lotus ornithopodiodes* L.**	0	0	1	0	0	1	02
***Lotus peregrinus* L.**	2	0	1	1	0	0	04
Medicago turbinata* L. *All.	2	1	0	4	0	1	08
***Medicago polymorpha* L.**	2	0	0	0	0	1	03
Pisum syriacum Boiss.	1	0	1	0	0	0	02
***Scorpiurus muricatus* L.**	0	1	2	0	0	1	04
Trifolium clusii Godr.et Gren.	0	3	3	0	3	1	10
***Trifolium purpureum* L.**	7	4	9	2	1	4	27
***Trifolium tomentosum* L.**	38	24	24	24	21	13	144
Trigonella kotschyi Fenzl. ex Boiss.	0	0	3	1	1	3	8
Trigonella caelesyriaca Boiss.	1	0	0	0	1	1	3
***Trigonella spinosa* L.**	2	0	1	1	0	0	4
***Vicia peregrenia* L.**	3	2	6	1	2	2	16

At Samta site, a total of 17 species were observed (Table 3). The dominant species was *L. cicera*; it represented 42% of the total plant species at Samta site. *T. tomentosum* came second followed by *Trigonella kotschyi*. Only three plants of each of *Medicago turbinata, S. muricatus* and *Trigonella caelesyriaca* were found in the survey plot at Samta site. At Rayyan site, a total of 17 species were observed (Table 4). The dominant species were *L. cicera* and *T. tomentosum* representing 66% of the plant species found at Rayyan site, while the least dominant species were *L. ornithopodiodes* and *Pisum syriacum*.

Across the three sites, the most dominant species were *L. cicera* and *T. tomentosum*. They were found in higher numbers in the three sites ranging from 29 to 206 and 62 to144 plants per site, respectively.

The results of the species' distribution, the manner in which groups of species are spread out, showed that out of the 1162 plants detected at the three surveyed sites, *L. cicera* and *T. tomentosum* were represented by 380 and 319 individuals, respectively, which make up 60% of the total number of plants. Other species such as *L. ornithopodiodes, S. muricatus* and *Trigonella caelesyriaca* were represented by less than 10 plants each at the three sites. The leading species, *L. cicera*, represented 33% of the total number of plants.

These results were consistent with those previously reported by Maliro et al. (2007), which showed high spatial diversity among different sites and regions. The comparison of our results with the previous studies (El-Oqlah and Lahham, 1985) indicated that the number of plant species and the number of plants per unit area decreased through time (years). For example, they reported the presence of six species of Lathyrus (*L. blepharicarpus, L. cicera, Lathyrus gorgonei, Lathyrus hierosolymitanus, Lathyrus inconspicuus* and *Lathyrus sativus*) in Ajloun area, while we found two of these species only, which means that four species of *Lathyrus* reported by them were not found in our study. The present result, therefore, shows the alarming danger of the phytogenetic erosion of pasture and forage legumes that is taking place in Jordan due to many threats that affect this ecosystem (Ajlouni et al., unpublished data).

Species' Importance

The results of the species' importance percentage (species' density, frequency and plant cover) are presented in Figures 1, 2 and 3. At Baoun site, the most important species was *T. tomentosum* followed by *L. cicera*, *T. spinosa* and *Lotus peregrinus*. On the other hand, the least important species were *A. cretaceus*, *L. ornithopodiodes* and *S. muricatus*, with an importance value of less than 2%. The most important species at Samta site was *L. cicera*, followed by *T. tomentosum*, *T. kotschyi*, *A. cretaceus* and *M. Turbinata*, while the least important species were *S. muricatus*, *T. caelesyriaca* and *L. peregrinus*.

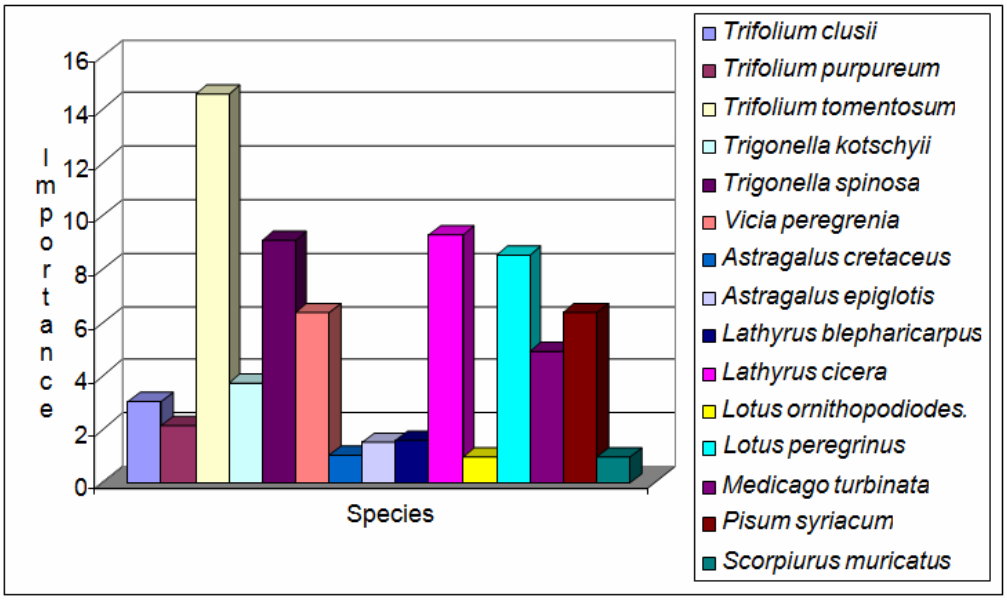

Figure 1: The relative importance of legumes plant species found at Baoun site in Ajloun area.

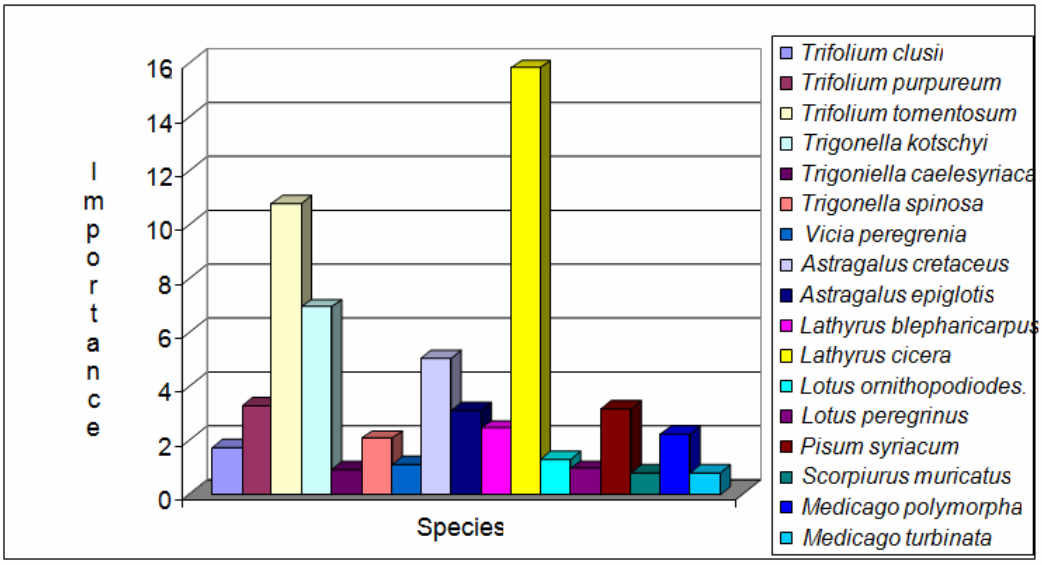

Figure 2: The relative importance of legumes plant species found at Samta site in Ajloun area.

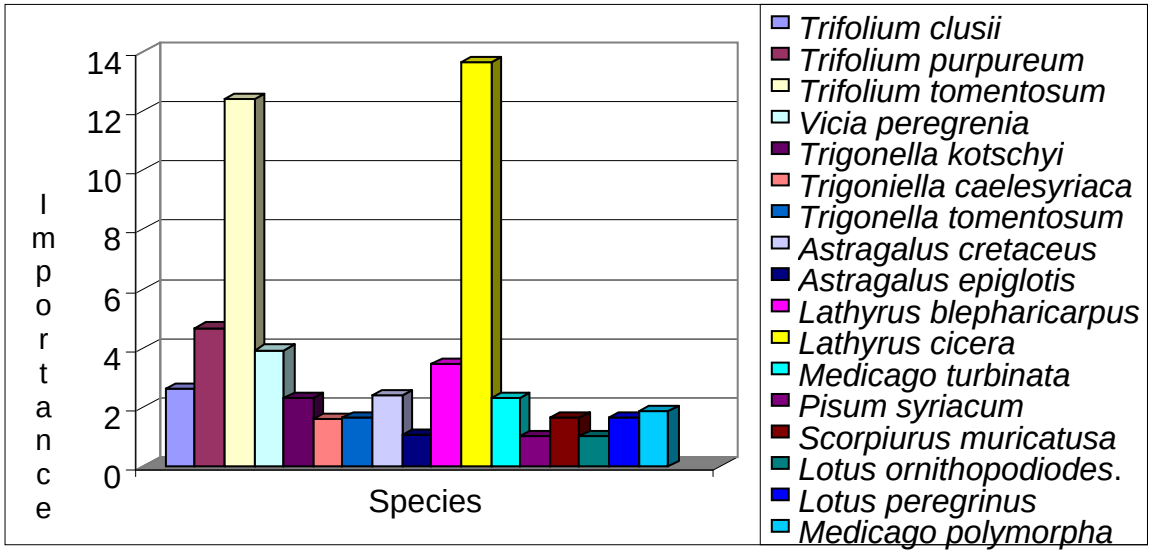

Figure 3: The relative importance of legumes plant species found at Rayyan site in Ajloun area.

Similar results to those at Samta site were found in Rayyan site, where *L. cicera* and *T. tomentosum* were confirmed to be the most two important species, and *P. syriacum* was the least important species.

Across all three sites, the results showed that *L. cicera* was the most important and effective species, followed by *T. tomentosum* and *T. spinosa*. On the other hand, the least important species were *S. muricatus* and *L. ornithopodiodes*.

Diversity Index

The diversity index values for the three sites studied are presnted in Table 5. The diversity index values ranged from 1.75 to 2.46 for all study sites. For Baoun site, the values of diversity index ranged from 2.03 to 2.40. However, for Samta site, the values of this index ranged from 2.00 to 2.46. On the other hand, Rayyan site had in general lower diversity index values ranging from 1.75 – 2.33.

Table 5: Shannon- Weaver diversity indices in the three monitoring sites of Ajloun area (2000-2004).

Site	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	The mean[1]
Baoun	2.28	2.25	2.20	2.40	2.03	2.18	2.22 a
Samta	2.19	2.46	2.24	2.00	2.14	2.12	2.19 a
Rayyan	1.77	1.75	2.00	2.33	2.06	2.1	2.00 a

[1] Means having the same letter are not significantly different.

The average diversity index values over the six transects are not significantly different from each other, even though Baoun site is found to show higher values for diversity index than the other two sites with less number of species and number of plants at the surveyed plot, implying that Baoun has a good species' distribution with evenness compared to the other sites. This site is a private owned area and semi-protected by the land owners from grazing. These results give more

evidence that the local community could play a key role in the *in situ* conservation of the local agrobiodiversity .

CONCLUSION

Ajloun area, with its richness in wild species and forage species of global importance, needs more efforts by local communities, government agencies and international institutions to preserve and sustainably use the remaining agrobiodiversity. Any future efforts for the establishment of protected areas should target the conservation of wild relatives of crops of global importance and other native species of forage, neglected species and medicinal plants. We propose to establish a natural reserve at or around Baoun site, in order to preserve and maintain the rich biodiversity , particularly the wild relatives of legume and cereal species. A management plan for this area needs to be developed with key local and national stakeholders. This management plan should include the sustainable use of the resources, increasing the awareness and finding alternative sources of income for local communities.

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التنوع والحماية في الموقع لأنواع البقوليات في النظام البيئي المتوسطي

م. عجلوني[1*]، أ. العقلة[2]، عبد اللطيف الغزاوي[3]، أ.م. الطّواها[4] وأحمد عمري[5]

ملخص

لدراسة التنوع في الأنواع البقولية في شمال الأردن، تم اختيار ثلاثة مواقع في منطقة عجلون هي سامتا والريان وباعون. وتم إجراء مسح نباتي خلال أربعة مواسم من عام 2000 إلى عام 2004. دلت النتائج على وجود تباين في عدد الأنواع التي تم التعرف عليها في المواقع الثلاثة . وظهر أن عدد الأنواع التي جمعت من سامتا والريان كان أعلى من التي جمعت من باعون. وتبين أيضًا أن الأنواع *Lathyrus cicera* و *Trifolium tomentosum* هي الأكثر انتشاراً في المواقع الثلاثة. أما قيم معامل التنوع (*Diversity index*) فقد تراوحت بين 1.75و 2.46 في جميع مواقع الدراسة. وكانت أعلى قيم له في موقع باعون. وتدل النتائج على أن منطقة عجلون غنية بالتنوع الحيوي لهذه الأنواع، وأنها تحتاج إلى جهود حثيثة للمحافظة على هذا الإرث العالمي سواءً في عين المكان أو في البنوك الوراثية.

الكلمات الدالة: بقوليات، التنوع الوراثي، النظام البيئي المتوسطي، الأردن.

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1) قسم الإنتاج النباتي، كلية الزارعة، جامعة العلوم والتكنولوجيا الأردنية، إربد، الأردن.

2) قسم العلوم الحياتية، كلية العلوم، جامعة اليرموك، إربد، الأردن.

3) قسم العلوم الحياتية والتقنية الحيوية، كلية العلوم، الجامعة الهاشمية، الزرقاء، الأردن.

4) قسم العلوم الحياتية، جامعة الحسين بن طلال، معان، الأردن.

5) المركز الدولي للبحوث الزراعية في المناطق الجافة (إيكاردا)، حلب، سورية.

* البريد الإلكتروني: majl@just.edu.jo

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