INTERNATIONAL JOURNAL OF ENVIRONMENT

**Volume-5, Issue-3, June-Aug 2016** **ISSN 2091-2854**

*Received:1 April* *Revised:29 April* *Accepted:5 August*

# INFLUENCE OF ALTITUDE AND SLOPE ON THE DENSITY OF *Asphodelus microcarpus* Salzm & Viv. IN THE MOUNT OF TESSALA (WESTERN ALGERIA)

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**Abstract**

The change in the structure of species communities along environmental gradients is a privileged field of ecology as it allows exploring a continuous progression of situations often in a small area, in this context, we are interested in studying the impact of altitude and slope on the density and the recovery rate of *Asphodelus microcarpus* population in mountainous ecosystem. *Asphodelus microcarpus* is an ecological model, which allows us to have an idea about the degree of degradation in mountainous ecosystem, the density increases with advanced degradation stage. Analysis of variance revealed a highly significant difference (P = 0.001) between the 20 selected stations. The principal component analysis revealed that the density is important in low altitudes around 750 m where the slopes are average, this correlation is the result of human pressures that weaken the mountain of Tessala.

Keywords: *Asphodelus microcarpus* Viv., altitude, slope, density, recovery, Tessala, Algeria

## Introduction

Algeria with over than 3000 species has considerable wealth of flora, including 232 species of medicinal aromatic and food use (Chenouf, 2005). In Northern Africa overgrazing is a process of continuous and alarming degradation (Bounejmate and El Murid, 2001; Acherkouk et al., 2005; Maatougui et al., 2005; El Zerey et al., 2009). The anarchic and irrational grazing remains one of the main causes of vegetation degradation (Dutilly-Diane et al., 2007).

Studies on the altitudinal variation of the diversity of communities usually focus on the analysis of species richness (Odland and Birks, 1999; Ohlemüller and Wilson, 2000; Kessler, 2000). The Mount of Tessala located in the North-Western part of Algeria, is home to a remarkable floristic richness, marked by the presence of plants with therapeutic properties such as thyme and others interesting species (Bouterfas, 2013; Fartout, 2014) but currently this area is under serious degradation problems (Bachir- Bouiadjra and El Zerey, 2014; Cherifi et al., 2014; El Zerey, 2014). The flora was the subject of several studies relating to particular ecological and biochemical valuation (El-Zerey Belaskri et al., 2013; Bouterfas el al., 2014; El Bouhissi et al., 2014). According Quézel and Santa (1962-1963), *A. microcarpus* is a perennial reaching 1.50 meters with many tuberous roots; the leaves from the base, are long 40 cm, gutter; flowers forming at the end of the stem and branches are represented by 6 tepals white-pink to purple rib. The fruit is an oval capsule.

However, little or no work has been done on the relationship between environment factors and density of species in this mountain. The objective of our work is to highlight the impact of altitude and slope on *A.microcarpus* Salzm and Viv. evolving in Mount of Tessala.

## Material and methods

### Study area

The study area is situated in the mountains of Tessala, geographically located in the North West, and distant 15 Km from of the city of Sidi Bel Abbes, these mountains are the central part of the Atlas Tell mountain with an altitude of 1061 m, also characterized by geographic isolation, and fragile ecosystems (Fig. 1). The area is known by rich flora, particularly developed in the forests of Tessala. The forest vegetation consists of oaks located on the Northern slope, the Kermes oak, scrub and open forests, composed mainly of Aleppo pine, but also by acacia and eucalyptus trees on the South side. The study area is characterized by a semi-arid climate with 450 mm rainfall; the maximum temperature is about 35.3 ° C, while the temperature of coldest month is around 1.4 ° C.

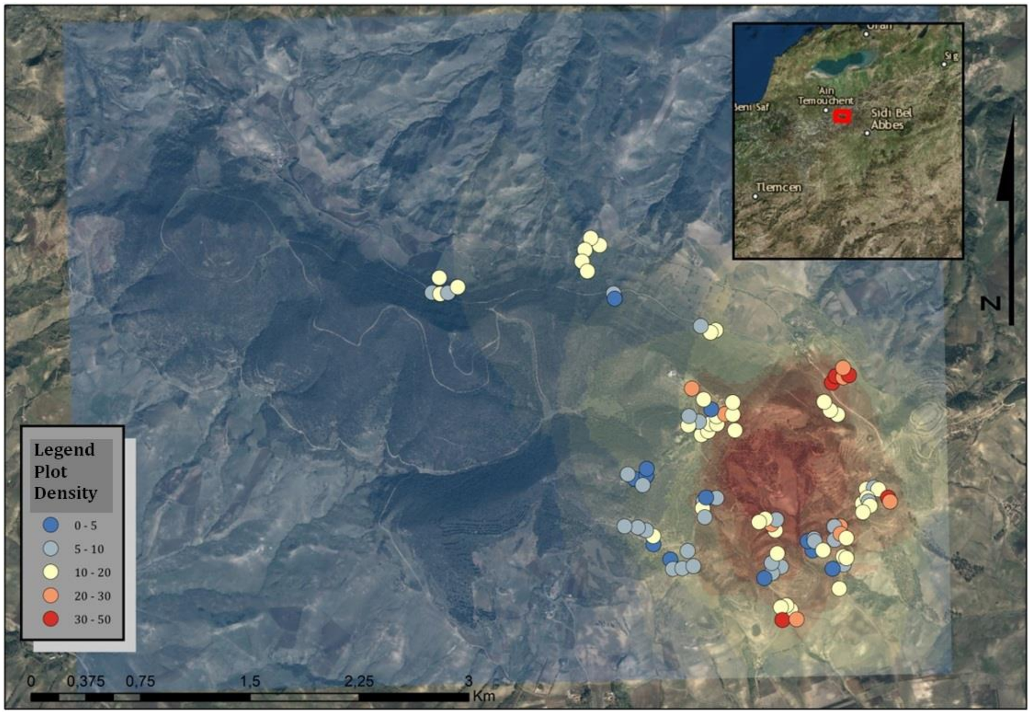


**Figure 1 - Location of sampling stations in the Mount of Tessala**

We selected 20 stations according to altitudinal gradient in both North and South side. The selection of the choice is based on the presence of *Asphodelus microcarpus*. In every station 05 floristic readings were taken and Soil characterization was done in 6 stations to understand the relation between soil and others environmental factors in the study area. Observations and measurements were done from January to April 2016 on plants in their vegetative stages. The characteristics of the sampling stations are summarized in Table 1.

**Table 1. Characteristics of sampling stations**

| Station | Floristic reading | Geographical coordinates | | altitude | Slope | Aspect |
|---|---|---|---|---|---|---|
| | | X | Y | | | |
| S1 | R1 | 35,264265 | -0,769033 | 757 | 17,15% | NE |
| | R2 | 35,264529 | -0,769336 | 750 | 19,72% | NE |
| | R3 | 35,264434 | -0,769759 | 738 | 47,00% | E |
| | R4 | 35,263644 | -0,769668 | 716 | 35,91% | E |
| | R5 | 35,263662 | -0,768603 | 723 | 28,72% | NE |
| S2 | R1 | 35,26693 | -0,76968 | 636 | 12,54% | SE |
| | R2 | 35,266555 | -0,770364 | 639 | 5,34% | SE |
| | R3 | 35,266256 | -0,770962 | 803 | 43,48% | NE |
| | R4 | 35,267173 | -0,77038 | 798 | 51,32% | NE |
| | R5 | 35,267758 | -0,769947 | 793 | 44,72% | NE |
| S3 | R1 | 35,269187 | -0,770055 | 769 | 20,71% | SW |
| | R2 | 35,269563 | -0,77032 | 775 | 15,14% | SE |
| | R3 | 35,269843 | -0,769944 | 771 | 15,67% | SE |
| | R4 | 35,269906 | -0,7708 | 757 | 14,63% | SE |
| | R5 | 35,26972 | -0,77127 | 752 | 21,33% | SE |
| S4 | R1 | 35,27108 | -0,775408 | 752 | 14,86% | SE |
| | R2 | 35,270648 | -0,7755 | 758 | 25,50% | S |
| | R3 | 35,270105 | -0,775334 | 754 | 16,27% | SW |
| | R4 | 35,271261 | -0,774426 | 753 | 23,52% | SW |
| | R5 | 35,271312 | -0,775214 | 744 | 14,94% | E |
| S5 | R1 | 35,267532 | -0,778002 | 751 | 15,44% | SW |
| | R2 | 35,266949 | -0,777822 | 748 | 14,94% | SE |
| | R3 | 35,266974 | -0,777116 | 741 | 20,54% | E |
| | R4 | 35,267098 | -0,776277 | 745 | 19,32% | S |
| | R5 | 35,268042 | -0,776692 | 742 | 29,48% | S |
| S6 | R1 | 35,268496 | -0,779254 | 717 | 21,77% | SE |
| | R2 | 35,268998 | -0,779261 | 729 | 16,20% | SE |
| | R3 | 35,269365 | -0,779778 | 731 | 19,81% | SE |
| | R4 | 35,269558 | -0,780402 | 725 | 26,50% | E |
| | R5 | 35,269653 | -0,781399 | 702 | 15,88% | E |
| S7 | R1 | 35,272559 | -0,780545 | 756 | 29,77% | S |
| | R2 | 35,272749 | -0,77967 | 765 | 15,91% | W |
| | R3 | 35,273156 | -0,779631 | 770 | 7,76% | S |
| | R4 | 35,272855 | -0,781064 | 768 | 11,45% | S |

| | | | | | | |
|---|---|---|---|---|---|---|
| | R5 | 35,272164 | -0,779955 | 755 | 26,98% | S |
| S8 | R1 | 35,275183 | -0,77545 | 812 | 34,80% | N |
| | R2 | 35,275393 | -0,774944 | 822 | 46,96% | NE |
| | R3 | 35,275848 | -0,774802 | 818 | 44,64% | NE |
| | R4 | 35,275822 | -0,774262 | 866 | 43,81% | N |
| | R5 | 35,275414 | -0,77292 | 881 | 41,27% | N |
| S9 | R1 | 35,276306 | -0,774278 | 874 | 43,33% | NE |
| | R2 | 35,276427 | -0,773645 | 867 | 41,28% | N |
| | R3 | 35,27639 | -0,773062 | 858 | 55,64% | N |
| | R4 | 35,277151 | -0,773033 | 828 | 29,48% | N |
| | R5 | 35,276742 | -0,77467 | 825 | 20,99% | N |
| S10 | R1 | 35,276004 | -0,775619 | 776 | 24,54% | E |
| | R2 | 35,275791 | -0,776425 | 785 | 13,36% | S |
| | R3 | 35,276354 | -0,776363 | 780 | 33,18% | NW |
| | R4 | 35,278058 | -0,77609 | 784 | 26,24% | NW |
| | R5 | 35,277368 | -0,775224 | 813 | 45,54% | N |
| N1 | R1 | 35,278226 | -0,765533 | 711 | 6,52% | SW |
| | R2 | 35,278608 | -0,765238 | 712 | 7,85% | S |
| | R3 | 35,278532 | -0,764668 | 709 | 6,59% | SW |
| | R4 | 35,278663 | -0,764246 | 713 | 14,68% | NW |
| | R5 | 35,279126 | -0,764673 | 709 | 18,25% | S |
| N2 | R1 | 35,256072 | -0,76463 | 775 | 26,20% | SE |
| | R2 | 35,256109 | -0,765041 | 772 | 39,81% | S |
| | R3 | 35,276242 | -0,765161 | 741 | 44,15% | S |
| | R4 | 35,276517 | -0,765717 | 786 | 20,09% | SW |
| | R5 | 35,277043 | -0,766151 | 793 | 21,64% | E |
| N3 | R1 | 35,2716 | -0,76312 | 786 | 32,15% | E |
| | R2 | 35,271695 | -0,76256 | 789 | 20,83% | NE |
| | R3 | 35,271576 | -0,762205 | 776 | 24,93% | NE |
| | R4 | 35,271052 | -0,761503 | 792 | 25,60% | NE |
| | R5 | 35,270798 | -0,761356 | 799 | 11,73% | SE |
| N4 | R1 | 35,27073 | -0,763439 | 852 | 42,62% | S |
| | R2 | 35,271068 | -0,763066 | 833 | 32,45% | SE |
| | R3 | 35,270843 | -0,762977 | 811 | 53,40% | SE |
| | R4 | 35,270567 | -0,762878 | 845 | 40,30% | SE |
| | R5 | 35,270186 | -0,763416 | 860 | 34,85% | SE |
| N5 | R1 | 35,269344 | -0,765149 | 839 | 17,42% | SE |

| | | | | | | |
|---|---|---|---|---|---|---|
| | R2 | 35,269345 | -0,765596 | 824 | 14,82% | E |
| | R3 | 35,268525 | -0,765599 | 819 | 22,05% | S |
| | R4 | 35,268876 | -0,765128 | 818 | 30,07% | SE |
| | R5 | 35,268615 | -0,764711 | 849 | 29,87% | S |
| N6 | R1 | 35,266978 | -0,764952 | 863 | 39,25% | SW |
| | R2 | 35,266729 | -0,765793 | 888 | 49,76% | SW |
| | R3 | 35,26747 | -0,764981 | 906 | 57,50% | S |
| | R4 | 35,267382 | -0,76474 | 913 | 59,46% | S |
| | R5 | 35,265501 | -0,765321 | 902 | 59,71% | S |
| N7 | R1 | 35,267883 | -0,767271 | 972 | 14,15% | S |
| | R2 | 35,268469 | -0,767634 | 985 | 16,34% | W |
| | R3 | 35,268613 | -0,767144 | 982 | 17,22% | N |
| | R4 | 35,268466 | -0,767104 | 975 | 9,92% | SW |
| | R5 | 35,267883 | -0,766491 | 970 | 22,91% | SW |
| N8 | R1 | 35,281623 | -0,774203 | 983 | 29,52% | NE |
| | R2 | 35,281499 | -0,774598 | 982 | 24,46% | S |
| | R3 | 35,281912 | -0,775323 | 994 | 15,42% | S |
| | R4 | 35,284027 | -0,781833 | 992 | 22,10% | S |
| | R5 | 35,28371 | -0,781749 | 970 | 44,79% | S |
| N9 | R1 | 35,284338 | -0,795497 | 1004 | 21,91% | SW |
| | R2 | 35,28425 | -0,794904 | 1013 | 12,38% | SW |
| | R3 | 35,2843 | -0,794309 | 1005 | 28,75% | E |
| | R4 | 35,284639 | -0,793573 | 999 | 36,08% | NE |
| | R5 | 35,285252 | -0,794933 | 1003 | 12,43% | W |
| N10 | R1 | 35,287031 | -0,782806 | 986 | 15,00% | W |
| | R2 | 35,287487 | -0,783457 | 989 | 26,15% | N |
| | R3 | 35,286764 | -0,783924 | 976 | 22,40% | W |
| | R4 | 35,286056 | -0,784152 | 1000 | 21,61% | SE |
| | R5 | 35,285441 | -0,783765 | 998 | 18,32% | W |

## Dendrometry Study

We performed an average of 7 squares in every floristic reading of *A. microcarpus*. The measured parameters are the number of plant per square metre, represented by the density and the recovery rate (%), the basic unit of our samples is square metre ($m^2$), (Fig. 2).

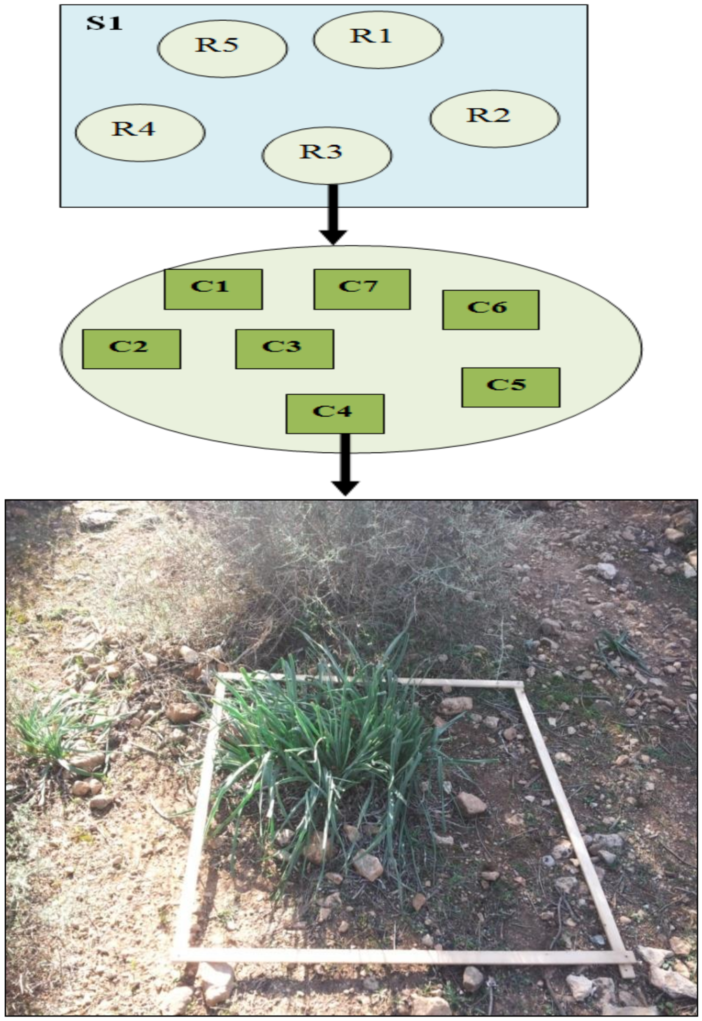


**Figure 2. Sampling Technique for a station with five statements**

S1: station1; R1: floristic reading 1; C1: Square 1

**Data processing**

Dendrometry parameters of 100 populations of *A. microcarpus* and characteristics of the environments presented by the altitude and slope were analysed by the principal component analysis (PCA) using Statistica 6.0 software. The matrix of this analysis consisted of 100 lines corresponding to the floristic reading of twenty stations and four columns representing the parameters of the studied area. This analysis summarizes the variability of these parameters for a reduced number of synthetic variables. The interpretation of the PCA made from the examination of the correlation and the position of the selected stations on the factorial axes (Phillippeau 1986).The average density and the recovery rate recorded in 20 stations are compared by analysis of variance (Legendre & Legendre, 1984a, b)

## Results and discussion

The presence of *A. microcarpus* populations in the study area, is a degradation sign of the natural plant cover, with the combined actions of overgrazing (Fig. 3) and the clearing of land. Table 2 shows the average values of the density and recovery assessed on *A. microcarpus* present in the selected stations. In the table 3 we note that the composition of soil in the different stations is characterized by, the dominance of the coarse and sand fraction in all stations. This increase of the coarse fraction can be related to the destruction of the soil by erosion. Moisture is very important in the station 2 (29.41 %), which is characterized by dense vegetation; while in the stations 1, 3 and 6 moisture is between 15% and 17 % while it is weak in other stations. The pH indicates a slight alkalinity of soils (pH > 7.50).

**Figure 3. Pasture in Southern slope in the study area**

**Table 2. Dendrometric Parameters of *A. microcarpus* within twenty sampling stations**

| Station | Density | | Recovery Rate (%) | |
|---|---|---|---|---|
| | South Side | North Side | South Side | North Side |
| *Station 1* | 31,23 ± 7,90 | 21,62 ± 6,76 | 21,57 ± 5,16 | 19,41 ± 3,41 |
| *Station 2* | 18,15 ± 3,43 | 7,41 ± 2,78 | 17,12 ± 2,40 | 11,81 ± 4,13 |
| *Station 3* | 15,97 ± 9,41 | 16,32 ± 5,18 | 16,48 ± 9,83 | 16,05 ± 3,61 |
| *Station 4* | 13,91 ± 3,29 | 8,18 ± 4,52 | 15,37 ± 4,30 | 10,67 ± 3,62 |
| *Station 5* | 16,97 ± 8,19 | 6,24 ± 1,40 | 18,45 ± 5,58 | 12,00 ± 1,70 |
| *Station 6* | 11,83 ± 6,64 | 7,60 ± 3,10 | 14,32 ± 8,01 | 14,20 ± 4,22 |
| *Station 7* | 6,64 ± 3,48 | 5,50 ± 2,29 | 11,98 ± 5,14 | 11,72 ± 3,21 |
| *Station 8* | 10,68 ± 5,69 | 14,44 ± 4,66 | 14,06 ± 4,24 | 14,48 ± 3,07 |
| *Station 9* | 11,51 ± 3,72 | 12,76 ± 6,71 | 18,12 ± 5,62 | 17,13 ± 4,59 |
| *Station 10* | 14,55 ± 2,73 | 15,03 ± 6,57 | 15,08 ± 1,10 | 17,75 ± 4,75 |
| Test of variance | + | | + | |

Spatial variability in soil organic matter varies between 1.05 and 4.55 %. According Duchaufour (1977), soils are considered rich in organic matter when the percentage of the organic matter is greater than 2 %. So, the stations 1, 2 and 3, are characterized with richness in organic matter, related to altitude. The distribution of the total and active limestone reveals the existence of three types of soil: slightly calcareous soil as the station 2; moderately limestone in the stations 1 and 3 and strongly calcareous soil of the station 5 **(Table 3)**.

**Table 3. Soil description according to altitudinal gradient**

| Station | station 1 | station 2 | station 3 | station 4 | station 5 | station 6 |
|---|---|---|---|---|---|---|
| Altitude | 1017 | 999 | 890 | 820 | 750 | 720 |
| coarse fractions | 36,39 | 39,17 | 34,45 | 32,85 | 17,88 | 29,4 |
| coarse sands | 28,57 | 32,05 | 25,69 | 26,78 | 19,01 | 27,91 |
| Fine sands | 27,23 | 24,93 | 35,74 | 37,3 | 56,07 | 39,46 |
| Silts | 4,17 | 1,14 | 2,45 | 1,95 | 2,14 | 1,03 |
| clays | 3,41 | 1,78 | 1,63 | 1,05 | 4,98 | 1,91 |
| Soil textures | Sandy loam | Sandblaster | Sandblaster | Sandblaster | Sandblaster | Sandblaster |
| Soil structure | Polyhedral | lumpy | lumpy | lumpy | Polyhedral | Polyhedral |
| Moisture | 17,65 | 29,41 | 16,67 | 12,26 | 11,54 | 15,38 |
| Organic matter | 2,71 | 4,55 | 3,08 | 1,78 | 1,48 | 1,05 |
| Total limestone | 47,59 | 2,59 | 41,38 | 1,03 | 51,72 | 33,1 |
| Active lime | 0,98 | 0,45 | 0,93 | 0,4 | 0,90 | 0,81 |

The analysis of variance shows a highly significant difference in the density of *A. microcarpus* between the different stations of the two slopes (P = 0.001). Regarding the recovery rate, the difference is significant to a 5% level (P = 0.05). These two parameters vary from one station to another (P = 0.001; P = 0.05), with a density and a maximum recovery respectively 31.23 order of ± 7.90 and 31.23 ± 7.90 characterize the population of the station 1 at low altitude located in the southern slope of Mount of Tessala. Low density values are noted in the stations 7, 5, 6 and 4 (5.50 ± 2.29, 6.24 ± 1.40, 7.60 ± 3.10, 8.18 ± 4.52) is a recovery rate of about 10.67 ± 3.62, 11.72 ± 3.21, 11.81 ± 4.13 respectively for stations 4, 7, 2 on the North slope of the study area.

Stations that have an inter-specific homogeneity are those with a reduced gap type recent, they are represented by the 10 Southern slope stations and station 5 at the North side. Moreover, we also note heterogeneity in the average plant density within individuals from each of the 20 populations. This diversity is reflected in the more or less important values of deviations. The PCA revealed that the factor axis 1 of the correlation circle has an inertia ratio of 47.88%, compared to the axis 2 with a smaller rate of around 23.13%.

Compared to the F1 axis, the PCA shows the existence of two groups (G1 and G2), (Fig. 4).

Taking into account the contributions that take each variable, the G1 group correlated with unit 1, 2, 3, 5 South side and Station 1 North Slope with density (0.880) and the recovery rate (0.829). The G2 group, correlated to stations 2, 4, 5, 6, 7, 8 North slope, consists of the following variables: altitude (ALT: -0.653), aspect (ASP: -0.643), the slope (-0.299).

Indeed, according to our observations, *A. microcarpus* appears approximately from 710 m above sea level and its development extends to 1004 m altitude. The presence of this species is correlated with the degree of degradation in the 20 stations. Low altitude areas seem to be exposed to livestock, unlike the high altitude areas where degradation damage is minimal, these stations are less exposed to the pressure of grazing (Fig 3).

Altitudinal gradients offer the opportunity to cover large amplitude of ecological situations over short distances (Baruch, 1984; Kitayama, 1992; Auerbach and Shmida, 1993).

According Schlüssel (1999), the number of taxa gradually decreases with altitude is in parallel with the decrease of cattle edible species. On the slopes of the highlands, particularly in cases of degraded formations, soil loss can take an alarming dimension. In the high mountains with very stretched slopes, the soil is washed away by the torrents, landslides, avalanches of mud, stone, snow, resulting in a depletion of soil essential elements with changes on the structure and the soil texture (Hans, 1998).

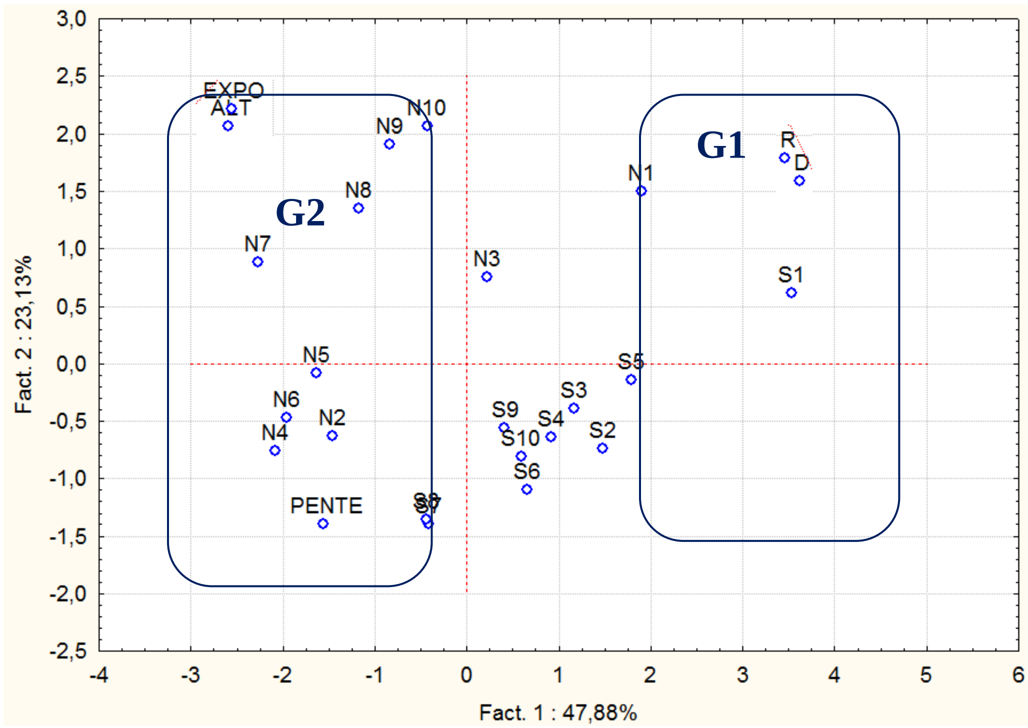


**Figure 4**. **Principal component analysis**

## Conclusion

Environmental factors have a direct influence on distribution of plants, especially in mountainous areas, the altitude and slope, the density and the recovery rate of *Asphodelus microcarpus* seem important in the study area. The presence of *A. microcarpus* populations in the study area, is a degradation sign of the natural plant cover, with the combined actions of overgrazing and the clearing of land. According to our observations, *A. microcarpus* appears approximately from 710 m above sea level and its development extends to 1004 m altitude. The presence of this species is correlated with the degree of degradation in the 20 stations. Low altitude areas seem to be exposed to livestock, unlike the high altitude areas where degradation damage is minimal. These stations are less exposed to the pressure of grazing. Also it would be interesting to perform the same type of study in other areas to have a more complete image of the effect of environmental factors on the development and richness of species in relation to the existing anthropogenic pressures.

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