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SUMMARIZING ADAPTIVE STRATEGIES OF SOME HIGH-MOUNTAIN PLANT SPECIES

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Abstract
High mountain regions are characterized by varied range of thermal conditions, short growing season and soils poor in nutrients. Because their high biodiversity, alpine habitats represent a great interest for world wild researchers. Many of those consider that alpine areas are harsh environments because their extreme conditions. In order to adapt at this environmental conditions, alpine plants have developed a series of defeating mechanisms. In this respect, the aim of this review is to explore some of those mechanisms that are involved in plants' adaptation process. Thus, this paper reflects the current status of knowledge regarding the adaptive strategies of some high mountain plant species. Irradiation, temperature and substrate are the environment conditions that are highlighted and for each were described a series of adaptive strategies. It was established that due to specific environmental conditions, which characterize the high mountains areas, the vegetation consists predominantly of shorter shrubs, meadows and plants growing on bare substrate. Plant species belonging to this vegetation are short, have low growth rates and high tolerance to low temperature. Also, in this paper, we try to clarify the "extreme condition" term by correlating it with the plants' adaptation capacity. Based on both personal and others authors works, we suggest a definition on this terms.

Keywords: Adaptation, alpine vegetation, extreme condition

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1. INTRODUCTION

The alpine ecosystems have a global importance, therefore it have been studied by word wild researchers.
Fritzmann (2010) stipulated that Humboldt and Aimé Bonpond described for the first time the mountain environment. These researchers studied altitudinal belts in a cross section of the Andes by linking physical parameters with biological observations. To this first observation many others were added, but it could not be given a unifying definition of high-mountain regions. Thus, various characterizations were made:
Nogués-Bravo et al. (2007) described mountain highlands as being very selective in terms of vegetation coverage and, also as biodiversity centers that house a large number of endemic species. Sundseth et al. (2005) have shown that as the altitude increases, the forests and the semi-natural grasslands that cover lower slopes are replaced with alpine grasslands, dwarf shrubs and plants growing on bare substrate.
Plants growing in alpine regions are faced with different challenges (Grill et al., 2005). Many researchers defined these challenges as stress conditions manifest manly by extreme abiotic condition (low temperatures, high winds, soils poor nutriment).
Cohen (2004) gives a more complete definition to stress condition: "as extreme levels of abiotic and biotic limiting factors relative to the distribution of the tolerance or utilization range of the dimensions or variables that define the habitats or the niche resources of the species".
For each of these harsh conditions, high-mountain plants develop a series of defense strategy, some of which it will be presented in this paper.

2. MATERIAL AND METHODS

This review was achieved after consulting different research studies to which were added some personal observations. These studies describe the alpine ecosystems with referring to plants' capacity to develop defense strategies for survival in harsh environment.

For exemplification were used some personal studies performed on alpine vegetation from Iezer-Papusa Mountains. The period in which the studies were conducted was the summer of 2011 and its aim consisted in identify the type of vegetation and observing the growth strategy of some plant species.

3. RESULTS AND DISCUSSION

Alpine environmental condition

Many researchers consider that alpine areas are harsh environments because their extreme conditions. Kőrner (1999) describes the alpine environment as being characterized by low temperature, short growing season and soils poor in nutrients. According to Nagy and Grabherr (2009), the alpine zones have a varied range of thermal conditions which are determined by direct incident solar irradiance. Becker and Bugmann (1997) described mountains by systematic changes in climatic parameters over very short distance. The Sundseth et al. (2005) studies have shown that the high mountain regions are characterized by a relatively cold and harsh climate and therefore the vegetation is reduced to only those adapted plants that are able to tolerate extreme conditions.

For a better understanding is necessary to clarify the term of "extreme condition". An environmental condition can be considered "extreme" or "normal" only in relation with a living organism. So, it's all about plants' capacity to meet the requirements of the environment by specific adaptation mechanism. Regarding to the process of plants adjustment to different environmental factors, Körner (2003) describes three ways in which this process can be achieved: by ontogenetic modification, by evolutionary adaptation and by acclimation or modulation. If the plants succeed to adapt to the demanding environmental condition by one of these three mechanisms, the "extreme" conditions became "normal" to the plants.

Adaptation at the irradiation

Because of the short growing season, alpine plant species have a mechanism for very efficient carbon assimilation (Oncel et al., 2004). The extreme climatic conditions and high levels of radiation with a higher UV proportion that exist in alpine mountain regions influence the photosynthesis process (Streb et al., 1998; Germino and Smith, 2000; Gril et al., 2005). In 1988, Körner and Larcher showed that photosynthesis is more efficient for highland vegetal species when high radiation and low temperature act together. In general, a high light intensity causes inactivation of the enzyme catalase and D1 protein, but for alpine species the defense mechanisms against oxidative damage are more effective.

Figure1. Alpine vegetation in Iezeru Massif

Shang and Feierabend (1998) compared the D1 protein turnover of three alpine species (*Homogyne alpina, Ranunculus glacialis, Soldanella alpina*) with one species from lowland (*Taraxacum officinale*). Observing these investigations revealed that alpine species have a greater resistance to high levels of radiation compared with species from lower mountain regions. According to Shang and Feierabend (1998) this is due light-dependent turnover of the D1 protein, which is contained by the alpine plants leaves.

Adaptation at temperature

In alpine ecosystems, temperature, particularly the lower ones, is one of the most important

factors that influence plant survival (Korner, 2003; Larcher et al., 2010).
Ruotsalainen (2003) consider that temperature can affect plants growth and development both direct and indirect way. Also, the action of temperature can interact antagonistic or synergistic with other factors which lead to amplifying or reducing its effects.
Because are protected by snow, low temperatures rarely affect alpine plants during winter. But in summer, plants need a defense strategy to adapt to low temperatures and usually are made by freezing tolerance or by prevention of ice nucleation (Hacker, 2011). Low temperatures in summer may determine that viable seeds not follow pollination. Because of this, some alpine plants have alternative methods of reproduction, such as rhizomes, layering, bulbs and stolons. The rhizomes help the parent plant to vegetative propagation and also enable a plant to survive an annual unfavorable season. By rhizomes system are interconnected many individual plants, this adaptation being extremely useful against frost-activity. Is important to highlight that because alpine plants develop alternative methods of reproduction (apomixes, vegetative reproduction), they don't lose their ability to produce seeds (Price, 1981; Billings and Mooney, 1968).
The plant growth stage is also very important. So, if at maturity, alpine plants can tolerate the existence of ice formations, those in the growth encountered high difficulty in the fight against frost. Larcher (1981) cited by Körner (2003), suggested that for increasing freezing tolerance, the plants develop some mechanism which induce a dehydration tolerance of cell membranes.
In alpine wet tropical areas there is large daily temperature amplitude. Thus, as an adaptation to the temperature gradient, in the alpine tropical environment were developed rosettes (Nagy and Grabherr, 2009). This morphological adaptation strategy is a solution to the environment pressure acting in high-altitude tropical regions.
Another adaptation form to temperature variation is represented by cushion plants.

Figure 2. Cushion plants (*Saponaria pumilio*)

Because of its capacity to respond to alpine environmental conditions, cushion plants are a common growth forms in alpine habitats. Its features (short, dense and compact stems) induce the formation of a microclimate with different proprieties from those of the surrounding area (higher temperatures, wind resistance, enhancing the survival of other species) (Cavieres et. al, 2007). In this respect, Körner (2003) cited by Molenda et. al (2012) shows that the microclimate created by some cushion plants maintains a temperature up to 15°K warmer than the ambient.

Adaptation at the substrate

An important factor to plants survival, development and distribution is represented by soil properties (porosity, nutrients amount, soil moisture and stability).
Even thought the alpine soil can accumulate a large amount of nitrogen, the mineralization and nitrification processes are low. Because of .3), azaleas *(Loiseleuria procumbens)* and short grasslands of *Carex curvula, Juncus trifidus, Festuca supina* (Doniţă et al., 2005; Makarov et al., 2009).
To this characteristic species is added *Primula minima*, *Phyteuma confusum*, *Agrostis rupestris*, *Campanula alpina*, *Senecio carpaticus, Euphrasia minima, Minuartia sedoides*, *Vaccinium gaultherioides*, *Nardus stricta, Festuca nigrescens*, *Ligusticum mutellina, Homogyne alpina.* (Species

encountered in alpine vegetation from Iezer-Papusa Mountains.)

Figure3. ***Salix herbacea***

Another strategy for high-mountain plants to increase their capacity for accumulation organic matter is to group in cushions. Nuñez C et al. (1999) suggests that for low-density plant population, cushion plants preserves the regional species by supporting a coexistence of a large number of species on a small vegetated area.

4. CONCLUSIONS

Due to the evolutionary process, alpine plants have developed many defeating strategies that allowed their existence in harsh living conditions.

In the alpine zone the lack of nutrients constrains the number of higher plants. Therefore, the high mountains vegetation consists predominantly of low herbaceous and dwarf shrubs. Plant species belonging to this vegetation are short, have low growth rates and high tolerance to low temperature. Due to low temperature the cell membrane of alpine plants has a high tolerance to dehydration and alternative methods of reproduction.

Because of the short growing season, alpine plant species develop a mechanism for very efficient carbon assimilation. It has been established that photosynthesis is more efficient for highland vegetal species when high radiation and low temperature act together.

It is considered that the term "extreme condition" must be used with some precaution because if a species has adapted to a certain environment conditions, those cannot be consider extreme anymore. So, an extreme condition for an organism can be defined as being the sum of biotic and abiotic factor which affect directly its natural develop and growth.

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