GEOGRAPHIC DISTRIBUTION OF PLANT GENETIC RESOURCES DIVERSITY IN KORCA REGION

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ABSTRACT
Geographic distribution of diversity for 257 geo-observations of ex situ and in situ plant genetic collections, including 44 species, from the four districts of Korca county was carried out, using grids of 5 x 5 km to assess the number of individuals per species and per district, the area of occupancy and diversity indices. Geospatial analysis detects areas of high alpha significant diversity. Combination of diversity indices as Species richness, Simpson index (1–D), Shannon index, Evenness, Brillouin index, Equitability and Fisher-alpha found the areas of Korca and Kolonja districts were richer and more even than other observed areas. Observed diversity in Korca areas was comparable with diversity of Kolonja areas, but the diversity among Devoll and Pogradec areas was non-comparable. Cluster analysis based on Euclidian distance (pair group method) generated a dendrogram of three clusters. Higher similarity (0.75) and significant positive correlation (r = 0.64) between diversity of Devoll and Pogradec district areas was found. Kolonja district areas show high species richness index, and the number of individuals distributed among species was more even (0.672) and equitable (0.857). These results suggest the presence of relative stable ecosystems and more ecological niches available in Kolonja areas. These diversity areas can be used for the assessment of the current status of conservation of plant genetic resources and for the prioritization of potential ecological areas suitable for in situ conservation.

Keywords: Diversity indices, geographic spatial analysis, species distribution.

1. INTRODUCTION
Albania is very rich in biological and landscape diversity, in cultivated crops and in wild plant species. Qosja (1973) identified near 1800 plant species in Korca region. This diversity is attributable to the country geographic position as well as geological, hydrological, climatic, and soil and relief factors. Plant genetic resources (PGR) play a key role in contributing to the sustainable development of agriculture, helping to increase agricultural food productions. Cultivated crops, medicinal and aromatic plants, fruit tree species, olive trees, and a great number of wild relatives are economically, socially, and culturally important plants grown over a wide range of ecological habitats in the country, in cultivated and wild habitats, in forest habitats, on the hills and mountains habitats. Wild plant species provide an invaluable source of genes that can be used for the improvement of cultivated species. The information on plants biodiversity in Albania is generally lacking especially in terms of species. There are still flora, taxonomic groups, especially crop wild relatives which are unknown or have not been studied.

Today, the conservation of genetic resources is regarded as an important need for human society. The genebanks offer the main means to explore, collect, store, and protect genetic materials, providing the raw material for the improvement of crops. The number of gene banks has increased steadily since they were first established in the 1920’s. According to the second report on The State of the World’s Plant Genetic Resources for Food and Agriculture, there are now some 1,750 gene banks worldwide, with about 130 of them each holding more than 10,000 accessions (FAO 2010). As the number of accessions or crops and wild species included in gene banks increases, the goals for PGR are focused on the quality of collections.
In this sense, assessment of geographic distribution and genetic diversity variation present in an ex situ collection is important for conservation of PGR and especially for the quality of ex situ collections.

Geographic information systems (GIS) are useful tools for eco-geographical analysis (Guarino et al., 2002). GIS studies using complex analyses visualize results of geographic distributions of biodiversity in clear maps, which are effective for management of a genebank (Jarvis et al., 2010; Gixhari et al., 2012). GIS studies provide important information about the diversity present in specific geographic areas (Maxted et al., 1995) and can be used to detect geographic distribution of a target species in ex situ collections and to identify collection priorities sites (Scheldeman et al., 2010).

Because the South Eastern part of Albanian territory has highly heterogeneous environmental conditions, and making more effective the collecting results using the application of GIS tools (Hijmans et al. 2012), the aim of this study was the assessment of the geographic distribution of PGR diversity in Korca County areas.

2. MATERIAL AND METHODS

Geographic distribution: The study for assessment of geographic distribution and genetic diversity of PGR is realized using ex situ data of PGR present in Albanian Gene Bank (AGB) database. It was conducted in four districts of Korca County: Devoli, Kolonja, Korca and Pogradec districts. Each taxon (plant species or population) represents a georeferenced observation. All geo-referenced observations, chosen to carry out spatial analysis, were entered into the GIS analysis, as presence points (Gixhari et al. 2014). Each presence point is spatially represented as point map using DIVA-GIS (Hijmans et al. 2012, 1999). The geographic areas, separated into small grid square cells of 5 x 5 km, were used to assess the geographic distribution, diversity indices, and richness estimators of plant species.

The analysis focuses only on the study of diversity at the species levels (unit of alpha diversity). Magurran (1988) define species diversity as consisting of two components: the number of species (richness) and how equally abundant the species are (evenness). The measurement of diversity and geographic distribution of plant species was realized analysing the number of observations per species and per district, the area of occupancy, where the total area occupied by a specific species, was selected as an indicator of abundance or rarity of a particular species.

Diversity indices: Indices as Species richness (S), Simpson index (1–D), Shannon index (H), Evenness (e^H/S), Brillouin index (B), Equitability (J), and Fisher's alpha (Fa) were the indices used to assess diversity and richness taking into account the respective proportions of each species in the study area. Species richness calculates the number of different species in a given area. Simpson index calculates the probability that two individuals randomly selected from a sample will belong to different species. The species evenness is the relative abundance or proportion of individuals among the species. Shannon-Weiner Index accounts for both abundance and evenness of the species present. The Brillouin index is used instead of the Shannon index when diversity of non-random samples or collections is being estimated. Equitability measures the evenness of individuals divided among the present species. Fisher's alpha - a diversity index, was defined by the formula \( S = a^n \ln(1 + n/a) \) where \( S \) is number of taxa, \( n \) is number of individuals and \( a \) is the Fisher's alpha. Diversity indices and richness estimators were calculated and mapped using CAPFOTOGENE tools (Parra-Quijano, 2011, 2012) and DIVA-GIS tools (Hijmans et al. 2012).

3. RESULTS AND DISCUSSION

Collecting and quality data: A large range of information for 276 accessions considered as presence data was gathered and recorded for each plant species during collecting data. For
data quality (Chapman 2005a) including the accuracy and precision of geographic coordinates firstly geo-referenced or presence data were checked for inconsistencies. Data points without coordinates were removed from ex situ PGR data. Data points with incorrect coordinates on the administrative unit (county and districts) were assigned coordinates where possible while duplicate or doubtful data were removed (Chapman 2005b; Scheldeman et al., 2010). All plant species were also screened carefully to resolve any scientific name conflicts (Chapman 2005b). The accessions not present physically as genetic material stored in genebank were also removed.

**Geographic distribution:** After checking the presence or absence of accessions the data included in the PGR database with partial or complete information for a total of 276 presence points, in total only 257 presence points for 44 species of plants were compiled and used to evaluate the geographic distribution, diversity of currently plant species observed in four districts of Korca County. Anova analysis proved the presence of significant differences ($F_{\text{ratio}} = 4.097^*$) at the $P_{0.00771} < P_{0.05}$ of the probability among the four observed areas analysed (Devolli, Kolonja, Korca and Pogradec districts) related to species richness and diversity indices (Table 1).

**Table 1. One-way ANOVA analysis of PGR diversity in Korca County areas.**

<table>
<thead>
<tr>
<th>Source</th>
<th>SumSquare</th>
<th>Degree of freedom</th>
<th>MeanSquare</th>
<th>$F_{\text{ratio}}$</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>173.381</td>
<td>3</td>
<td>57.7936</td>
<td>4.097*</td>
<td>0.007713</td>
</tr>
<tr>
<td>Within groups</td>
<td>2426.34</td>
<td>172</td>
<td>14.1066</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2599.72</td>
<td>175</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(*$*$) significant at the $P_{0.05}$ level of the probability.

![Figure 1. Geographic distribution of forty-four plant species in Korca County areas](image)

**Comparison of diversity indices:** Spatial analysis and diversity indices results detect the areas of high PGR diversity (Figure 1). Comparisons of diversity indices (Table 2) show the presence of an important variability in the study areas analysed and between observed areas/districts related to number of individuals (presence point) and kind of plant species present in those geographic areas. Species richness ($S$) clearly shows the higher number of different plant species was observed in Korca district areas ($S = 35$ species), followed by Kolonja district areas ($S = 16$ species). Higher number of individuals per species (3.97 and
3.56) was found respectively at Korca and Pogradec areas. Simpson index (1 - D > 0.80), and Brillouin index values (B > 2.0), clearly show the presence of higher diversity in areas of Korca and Kolonja districts. Shannon-Weiner index values (H > 2.30) show that areas of Korca and Kolonja district were richer than other areas. In the Kolonja district areas higher number of different species was found and the number of individuals distributed among species were more even (0.672) and equitable (0.857). High evenness (0.649) and equitability (0.803) was also observed in the Pogradec areas. In this study the Shannon index values ranges from 1.776 (Devoll areas) to 2.792 (Korca areas) showing in general mid species richness and evenness. Evenness (e^H/S), and Equitability (J) shows the higher evenness and variation in populations between the species, occurs in Kolonja and Pogradec district areas (Table 2).

Table 2. Diversity indices of plant species according to districts in Korca County.

<table>
<thead>
<tr>
<th>Diversity Indices / District areas</th>
<th>Devoll</th>
<th>Kolonjë</th>
<th>Korçë</th>
<th>Pogradec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taxa_S</td>
<td>11</td>
<td>16</td>
<td>35</td>
<td>9</td>
</tr>
<tr>
<td>Individuals</td>
<td>36</td>
<td>50</td>
<td>139</td>
<td>32</td>
</tr>
<tr>
<td>Simpson_1-D</td>
<td>0.749</td>
<td>0.873</td>
<td>0.892</td>
<td>0.764</td>
</tr>
<tr>
<td>Shannon_H</td>
<td>1.776</td>
<td>2.375</td>
<td>2.792</td>
<td>1.765</td>
</tr>
<tr>
<td>Evenness_e^H/S</td>
<td>0.537</td>
<td>0.672</td>
<td>0.466</td>
<td>0.649</td>
</tr>
<tr>
<td>Brillouin</td>
<td>1.459</td>
<td>2.002</td>
<td>2.478</td>
<td>1.457</td>
</tr>
<tr>
<td>Equitability_J</td>
<td>0.741</td>
<td>0.857</td>
<td>0.785</td>
<td>0.803</td>
</tr>
<tr>
<td>Fisher alpha (Fα)</td>
<td>5.401</td>
<td>8.137</td>
<td>15.050</td>
<td>4.163</td>
</tr>
</tbody>
</table>

Presence of high species diversity observed in Korca district areas suggests presence of a greater number of species and relative stable ecosystems were used by different collecting missions organized time to time. Shannon (H), Evenness (e^H/S), and Equitability (J) indices also suggests relatively less plant species presence will be expected in the Korca, Pogradec and Devoll habitats in the future, as the environmental changes and increased disturbed activities are more likely to be damaging to the ecosystem as a whole. Comparison of diversity indices suggests Kolonja district areas present more relative stable ecosystems and ecological niches. In these areas a greater number of different species important for conservation should be still available in the future.

Comparison of diversity among the observed areas using Tukey's pairwise test (Q), show the presence of important differences related to species richness and genetic diversity among Korca and Devoll areas (4.1340**), among Korca and Pogradec areas (4.2950**) significant at the P_0.00182 and at the P_0.00128 < P_0.01 of the probability (Table 3). There were also significant differences of diversity observed (3.5720*) among Kolonja and Korca district areas.

Table 3. Comparison of diversity among observed areas using Tukey's pairwise test (Q below diagonal) and the respective probability p (above diagonal)

<table>
<thead>
<tr>
<th>Observed areas</th>
<th>Devoll</th>
<th>Kolonjë</th>
<th>Korçë</th>
<th>Pogradec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Devoll</td>
<td></td>
<td>0.9788</td>
<td>0.0182</td>
<td>0.9995</td>
</tr>
<tr>
<td>Kolonjë</td>
<td>0.5619</td>
<td></td>
<td>0.0560</td>
<td>0.9565</td>
</tr>
<tr>
<td>Korçë</td>
<td>4.1340**</td>
<td>3.5720*</td>
<td></td>
<td>0.0128</td>
</tr>
<tr>
<td>Pogradec</td>
<td>0.1606</td>
<td>0.7225</td>
<td>4.2950**</td>
<td></td>
</tr>
</tbody>
</table>

(****) (*) significant respectively at the P_0.01 and P_0.05 level of the probability

Diversity profiles analysis dependent upon a single continuous parameter alpha (Tothmeresz 1995), show the diversities among Korca district (green line) and Kolonja district (dark blue line) and Devoll and Pogradec districts (respectively red and light blue lines) are comparable.
But the diversity among Devoll and Pogradec districts (where red line cross light blue line) are non-comparable among them (Table 3, Figure 2).

Figure 2. Diversity profile among Devoll, Kolonja, Korca and Pogradec districts areas

Cluster analysis: Comparisons of diversity indices (Table 2) using cluster analysis based on Euclidian distance (pair group method) generate a dendrogram with three cluster groups. Cluster analysis on correlations found higher similarity (0.75) and positive correlation ($r = 0.541^{**}$, significant at the $P_{0.01}$) between Devoll and Pogradec areas. There were high similarity (0.64) between Kolonja and Pogradec areas ($r = 0.542^{**}$), and among Devoll and Kolonja district areas significantly correlated among them ($r = 0.435^{**}$) (Figure 3).

Figure 3. Dendrogram of similarity (Euclidian distance) among four districts of Korca

The geographic distribution of PGR diversity study proved important information about the diversity present in the four specific geographic areas of Korca County. Results of this study,
congruent with results of Guarino et al., (2002); Parra-Quijano et al., (2012); Gixhari et al., (2014); suggest that the ecological areas of Kolonja can be used for the assessment of the current conservation status of plant genetic resources and for the prioritization of potential ecological areas suitable for in situ conservation.

4. CONCLUSIONS:
- Spatial analysis found significant differences of diversity between observed areas, and detects the area of high (alpha) was Korca district.
- Diversity observed in Korca and Kolonja district areas was comparable with diversity present in Devoll and Pogradec districts areas, but the diversity among Devoll and Pogradec areas were non-comparable.
- Ecosystems of Korca district areas highly used by collecting missions organized in different periods, suggests less relative stable ecosystems and ecological niches should be still available for conservation in the future.
- Diversity observed in Kolonja district areas (high species diversity and more evenness), suggests presence of more relative stable ecosystems and ecological niches. In these areas a greater number of different species important for conservation should be still available in the future.
- The results of the study suggest the ecological areas of Kolonja can be used for the assessment of the current status of genetic resources conservation and for the prioritization of potential ecological areas suitable for in situ conservation.

5. RECOMANDATIONS:
- Spatial analysis can be used successfully to estimate genetic, species and ecosystem diversity of different regions.
- Diversity indices, providing important information about the composition of a community, can be used in many fields of study to assess the diversity of any population in which each member belongs to a unique group, type, or species.
- Eco-geographic studies providing critical information about the diversity present in specific geographic areas can be used for the assessment of the current conservation status of plant genetic resources and to prioritize areas for in situ conservation.

6. REFERENCES: