RESEARCH PAPER

The Phenetic Study of Distributed Species of Valerianaceae Batsch Family in Kurdistan Region-Iraq

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ABSTRACT:
The present study was conducted in Kurdistan region of Iraq, the field trips from all geographical districts of the region have been done during the years (2016-2018). The species of Valerianaceae family have been collected from the Jabal Sinjar (MJS), Amadiya (MAM), Rowanduz (MRO), Sulaimaniya (MSU), Erbil (FAR), Kirkuk (FKI), Upper Jazeera (FUJ), and Persian Foothills (FPF) districts within the studied area. The various characters of morphological, anatomical, palynological and cytological studies have been analyzed. The achieved data were processed by MVSP windows program, and the different dendrograms are constructed for each cluster attributes to determine the various relationships among the studied species.

KEY WORDS: Iraq, Kurdistan Region, Phenetic study, Valerianaceae.
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1. INTRODUCTION:

The term of phenetic was initiated by Cain and Harrison (1960) to express a correlation of overall similarities and relationships among taxa (Sneath and Sokal, 1973), depending on all available features without any weighting (Stuessy, 1990). Numerical analysis of taxonomy is recently best known to a phenetic (Mondal, 2009), also called taxometrics Rogers (1963) and Mayer (1966), or multivariate morphometrics (Blackith and Reyment, 1971).

(Sneath and Sokal, 1973) interpreted that the sensible crucial unit in a large majority part of examples is the individual organs. The individuals are the fundamental units applied, would throw light on resemblances among intraspecific variants, but would not be likely to offer much scope for comparisons at the sub-generic, generic, and higher levels. The comparisons of numerous individuals would lead to similarity matrices of excessive size and therefore be an individual (or an average) standing for a race, a species, a genus or a higher ranked taxon. (Sokal, 1966; 1986) believes the numerical taxonomic relations of three kinds: the phenetic, cladistic (close cladistic, close phenetic similarity) and chronistic or temporal.

The phenetic taxonomy is arrangement the operational taxonomic units (OTUs) in a stable and convenient classification (Sokal, 1966). There are units such as individuals, genera, and family which calculate the similarity. Taxonomic characters are attributes of a member of a taxon by which it differs from a member of different taxa. In selecting taxonomic characters, it is wise to
avoid characters that do not reflect the inherent nature of the OTU or are the logical correction to other units or are invariant. In addition, an a priori weighting of each taxonomic characteristic must be equal (Pedersen et al., 2001).

The Valerianaceae family comprises 10 genera and 370 species (Lawrence, 1951), and consists of 10 genera about 300 species, mostly annual or perennial herbs, the leaves are opposite, estipulate, inflorescence is bracteates, composed of cyme units. The calyx of 5 sepals or reduced to teeth, and/or forming an accrescent pappus in some taxa, the corolla is gamopetalous with 5 [3,4] imbricate lobes and saccate or spurred. Stamens are 1-4, whorled, gynoecium is 3 carpelled, syncarpous, ovary inferior with one fertile and two sterile locules. Fruit is an achene, sometimes cypsela. Seeds have an oily endosperm (Simpson, 2006). The final number of the genera and species of the family are counted by (Takhtajan, 2009) were: Belonanthus: 5 species; Centranthus: 9 species; Nardostachys: 1-2 species; Patrinia: 15 species; Phyllactis: 25 species; Plectristis: 5 species; Stangea: 7 species; Valeriana: 250 species; Valerianella: 50 species. In APG III (2009) system, the Caprifoliaceae expanded to include Diervillaceae, Dipsacaceae, Linnaeaceae, Morinaceae, and Valerianaceae.

In Iraq the lists of Valerianaceae genera and species included as: (Guest, 1933) cited the presence of 7 species of Valerianella, (Blakelock, 1948) only 2 species of Valeriana, with 7 species of Valerianella, (Zohary, 1946) pointed out the presence of 2 species belonging to the genus Valeriana and 10 species of Valerianella. While (Rechinger, 1964) listed 13 species belonging to the Valerianella, (Al-Rawi, 1964) mentioned the presence of 1 species of Centranthus, and 2 species of Valeriana and 15 species of Valerianella, (Rechinger, 1969) pointed out the presence of 1 species of Centranthus; 2 species of Valeriana and 15 species of Valerianella most of them distributed in Iraqi Kurdistan.

The list of (Ridda and Daood, 1982) included 1 species of Centranthus, 2 species of Valeriana and 15 species of Valerianella, finally, (Ghazanfer and Edmondson, 2013) elucidated 1 species belonging to Centranthus, 2 species belonging to Valeriana and 15 species belonging to Valerianella.

The current study attempts to reconsider the comprehensive similarity and dissimilarity of Valerianaceae members and investigate the relationships and diagnostic ability of morphological, anatomical, palynological and cytological evidence to separate the studied taxa.

2. MATERIALS AND METHODS

In the current study, the numerical methods have been applied for investigating the morphological, anatomical, palynological and cytological relationships among the studied taxa of Valerianaceae family. The individuals used as OTUs, both quantitative and qualitative characters were used. Cluster analysis by UPGMA (Unweighted Pair-Group Method using arithmetic Averages)

Cluster analysis was achieved by MVSP (Multi Variate Statistical Package) for Windows, version 3.22. The characters states were taken from the different features for the purposes of analyzing each of the variants as follows:

1- 32 key characteristics were taken for numerical analyzing for 3 genera of the family.
2- The taken morphological characters for numerical analyzing were 64 characteristics for all studied taxa.
3- The taken anatomical characters for numerical analyzing were 66 characteristics for all family's taxa.
4- The taken chromosomal characters for numerical analyzing were 6 characteristics for all family's taxa.
5- The taken palynological characters for numerical analyzing were 9 characteristics for 14 taxa of the family.

The similarity and dissimilarity have been collected by comparing each OUT with all other OTUs, all the data from the individual sets were consolidated to carry out the whole of 64 characters states analysis, include 15 species within 3 genera which belonging to Valerianaceae.

For all the data sets, similarity coefficients \( S(j,k) \) was calculated to measure the similarity among OUT \( j \) and \( k \), using GGSc (Gower General Similarity coefficient) that elucidated by (Pedersen et al., 2001).

\[
S(j,k) = \frac{\sum_{i=1}^{n} W_{ij,k} s_{ij}}{\sum_{i=1}^{n} W_{ij,k}}
\]

\( I = \text{the \textit{i}th character } \epsilon \{1, \ldots, n\} \)
Subsequently, the similarity coefficient was calculated by Gower that was used to construct dendrograms using UPGMA.

3. RESULTS:

3.1. The general relationship within genera:

The dendrogram of Valerianaceae genera and the similarity coefficient shows that the higher similarity at \( \text{GGSc}=0.625 \) is between the two genera *Centranthus* and *Valeriana*, the reasons of convergence refer to the affinity or similarity in their height, perennial duration, mountain habitat, the presens or absens of the trichomes, number of fruit locules, variation in inflorescence types, and chromosome numbers. The genus *Valerianella* meets with the two genera *Centranthus* and *Valeriana* at the lower level \( \text{GGSc}=0.188 \), the divergence of the genus from them is caused by the dissimilarity at the previous mentioned attributes. Figure (1) and table (1).

![Figure (1): Dendrogram of the similarity degrees among Valerianaceae genera.](image)

| Similarity matrix   | Centranthus | Valeriana | Valerianella |
|---------------------|-------------|-----------|--------------|
| Centranthus         | 1.000       |           |              |
| Valeriana           | 0.625       | 1.000     |              |
| Valerianella        | 0.156       | 0.219     | 1.000        |

3.2. Morphology:

The similarity coefficient for morphology data sets was cleared in table (2), and the dendrogram formed by cluster analysis of morphology showed in figure (2). The absolute similarity is marked by 1.000. At the upper level \( \text{GGSc}=0.938 \), *Valeriana alliariifolia* and the *Valeriana sisymbriifolia* are similar. At the level \( \text{GGSc}=0.813 \) the *Centranthus longiflorus* is single in group *Va. alliariifolia*, *Va. sisymbriifolia* and *C. longiflorus*. The level which they are meted is depended on an average of values of the unweighted arithmetic. The relationship of the species of former both genera to the *Valerianella* species is correlated in the very low level at \( \text{GGSc}=0.434 \).
Table (2): Similarity matrix coefficient of morphological characters for Valerianaceae taxa.

Among the Valerianella species, Valerianella coronata and Valerianella vesicaria are similar at the level GGSc=0.938, this pair meets Valerianella kotschyi, Valerianella dactylophylla, and Valerianella discoida at levels GGSc= 0.906, 0.849 and 0.816 respectively. Valerianella szovitsiana and Valerianella oxyrrhyncha are similar at level GGSc=0.859, and Valerianella carinata and Valerianella pumila similar at level GGSc=0.828 and GGSc=0.724, and both of them are also included in group. Valerianella tuberculata, Valerianella dufresnia, and Valerianella muricata, are more similar than V. coronata and V. vesicaria which contacted at the level GGSc=0.698.

3.3. Palynology:
The similarity coefficient for pollen morphology data sets was cleared in table (3), and the dendrogram formed by cluster analysis of pollen morphology showed in figure (3). The absolute similarity is marked by 1.000. According to the resultant dendrogram indicating to a close affinity among the OTUs as V. oxyrrhyncha, V. tuberculata and V. szovitsiana which are similar at the absolute level 1.000, and the OTUs V. dufresnia, V. dactylophylla and V. discoida which are similar at the absolute level 1.000. These two groups are similar to each other at the level GGSc=0.778. The V. carinata, Va. sisymbrifolia, and V. muricata are similar at the level GGSc=0.778, and the Va. alliariifolia and V.
pumila are similar at the level GGSc=0.778, this confusion between the species of the two genera suggests the indistinctness of pollen grain in family’s taxa delimitation. V. coronata, V. kotschyi, and V. vescaria are similar at the level GGSc=0.833, connects the former groups at the low level of GGSc=0.566, and all groups converge at the lowest similarity level GGSc=0.471, with a less similar cluster of V. carinata, Va. sisybrifolia, and V. muricata.

Table (3): Similarity matrix coefficient of pollen morphology characters for Valerianaceae taxa.

| CLUSTER ANALYSIS | UPGMA | Data in random input order |
|------------------|-------|---------------------------|
| Imported data - Palynological data: Analyzing 9 variables (characters) x 14 cases (species) | Gower General Similarity Coefficient | Similarity matrix |
| Va. alliarifolia | 1.000 | Va. alliarifolia 0.556 Va. pumila 0.778 Va. coronata 0.333 Va. vescaria 0.333 Va. carinata 0.233 V. tuberculata 0.707 V. oxyrhyncha 0.778 V. dactylophylla 0.556 V. discoidea 0.556 |
| Va. pumila | 0.556 1.000 | Va. coronata 0.778 0.778 0.333 0.333 Va. vescaria 0.333 Va. carinata 0.233 V. tuberculata 0.707 V. oxyrhyncha 0.778 V. dactylophylla 0.556 V. discoidea 0.556 |
| Va. vescaria | 0.333 0.333 0.556 0.333 0.333 0.833 1.000 | Va. carinata 0.233 V. tuberculata 0.707 V. oxyrhyncha 0.778 V. dactylophylla 0.556 V. discoidea 0.556 |
| Va. carinata | 0.556 0.556 0.333 0.333 0.333 0.833 1.000 | Va. coronata 0.778 0.778 0.333 0.333 Va. vescaria 0.333 Va. carinata 0.233 V. tuberculata 0.707 V. oxyrhyncha 0.778 V. dactylophylla 0.556 V. discoidea 0.556 |
| Va. coronata | 0.333 0.333 0.556 0.333 0.333 0.833 1.000 | Va. vescaria 0.333 Va. carinata 0.233 V. tuberculata 0.707 V. oxyrhyncha 0.778 V. dactylophylla 0.556 V. discoidea 0.556 |
| Va. vescaria | 0.233 0.233 0.778 0.233 0.778 1.000 | Va. carinata 0.233 V. tuberculata 0.707 V. oxyrhyncha 0.778 V. dactylophylla 0.556 V. discoidea 0.556 |
| V. tuberculata | 0.707 0.707 0.556 0.556 0.556 0.833 1.000 | Va. coronata 0.778 0.778 0.333 0.333 Va. vescaria 0.333 Va. carinata 0.233 V. tuberculata 0.707 V. oxyrhyncha 0.778 V. dactylophylla 0.556 V. discoidea 0.556 |
| V. oxyrhyncha | 0.778 0.778 0.556 0.556 0.556 0.833 1.000 | Va. coronata 0.778 0.778 0.333 0.333 Va. vescaria 0.333 Va. carinata 0.233 V. tuberculata 0.707 V. oxyrhyncha 0.778 V. dactylophylla 0.556 V. discoidea 0.556 |
| V. dactylophylla | 0.556 0.556 0.333 0.778 0.233 0.778 0.556 1.000 | Va. coronata 0.778 0.778 0.333 0.333 Va. vescaria 0.333 Va. carinata 0.233 V. tuberculata 0.707 V. oxyrhyncha 0.778 V. dactylophylla 0.556 V. discoidea 0.556 |
| V. discoidea | 0.556 0.556 0.333 0.778 0.233 0.778 0.556 1.000 | Va. coronata 0.778 0.778 0.333 0.333 Va. vescaria 0.333 Va. carinata 0.233 V. tuberculata 0.707 V. oxyrhyncha 0.778 V. dactylophylla 0.556 V. discoidea 0.556 |
| Va. alliarifolia | 0.556 0.556 0.333 0.778 0.233 0.778 0.556 1.000 | Va. coronata 0.778 0.778 0.333 0.333 Va. vescaria 0.333 Va. carinata 0.233 V. tuberculata 0.707 V. oxyrhyncha 0.778 V. dactylophylla 0.556 V. discoidea 0.556 |

Figure (3): Dendrogram of pollen characters, the similarity degrees among studied taxa of Valerianaceae.

3.4. Anatomy:

The similarity coefficient for pollen morphology data sets was cleared in table (4), and marked by 1.000. The anatomical analysis dendrogram showed that the two species V. muricata and V. pumila have high similarity at level GGSc=0.848, whereas the species V. dactylophylla is more similar with V. oxyrhyncha at level GGSc=0.808 than V. muricata and V. pumila which they made a group with V. tuberculata and V. carinata at different levels. The other OTUs group of V. vesicaria, V. kotschyi, V. coronata, V. dufresnia, and V. discoidea have similarity at different levels. At level GGSc=0.716 there are two groups: Va. alliarifolia with C. longiflorus, and Va. sisybrifolia with former groups. Finally, V.

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szovitsiana has single clade sister at lower similarity level GGSc=0.683, and suggesting the less resemblance with all other family's taxa.

Table (4): Similarity matrix coefficient of anatomical characters for Valerianaceae taxa.

| Cluster Analysis | UPGMA |
|------------------|-------|
| **Gower General Similarity Coefficient** | **Similarity matrix** |
| **C. longiflorus** | **V. alliariifolia** | 0.818 | 1.000 |
| **V. szovitsiana** | 0.742 | 0.803 | 1.000 |
| **V. pumila** | 0.727 | 0.773 | 1.000 |
| **V. coronata** | 0.742 | 0.803 | 0.773 | 1.000 |
| **V. americana** | 0.697 | 0.697 | 0.773 | 0.848 | 0.803 | 1.000 |
| **V. dufresnia** | 0.652 | 0.652 | 0.697 | 0.712 | 0.788 | 0.773 | 1.000 |
| **V. kotschyi** | 0.652 | 0.652 | 0.667 | 0.733 | 0.788 | 0.758 | 1.000 |
| **V. vesicaria** | 0.742 | 0.773 | 0.697 | 0.773 | 0.788 | 0.733 | 0.758 | 0.818 | 1.000 |
| **V. diffusa** | 0.636 | 0.697 | 0.742 | 0.727 | 0.773 | 0.788 | 0.733 | 0.758 | 0.773 | 1.000 |
| **V. tuberculata** | 0.742 | 0.773 | 0.788 | 0.818 | 0.803 | 0.727 | 0.758 | 0.773 | 0.712 | 1.000 |
| **V. oxyrrhyncha** | 0.667 | 0.697 | 0.773 | 0.818 | 0.803 | 0.818 | 0.733 | 0.773 | 0.758 | 0.773 | 1.000 |
| **V. dactylophylla** | 0.727 | 0.727 | 0.742 | 0.818 | 0.803 | 0.818 | 0.733 | 0.773 | 0.758 | 0.773 | 1.000 |
| **V. dufresnia** | 0.652 | 0.682 | 0.697 | 0.742 | 0.788 | 0.773 | 0.788 | 0.818 | 0.803 | 0.712 | 0.727 | 0.773 | 0.803 | 1.000 |

Figure (4): Dendrogram of anatomical characters, the similarity degrees among studied taxa of Valerianaceae.

3.5. Cytology:

The similarity coefficient for cytology data sets was cleared in table (5), and the dendrogram formed by cluster analysis of cytology showed in figure (5). The absolute similarity is marked by 1.000. The dendrogram constructed from cytological investigation, revealed that the cluster of V. discoidea, V. vesicaria, V. coronata, and V. pumila, and cluster of V. dactylophylla, V. dufresnia, V. muricata, V. sisyembrifolia and V. alliariifolia were similar at absolute level, and they have a low similar level at GGSc=0.625. These two groups are more similar than the cluster of C. longiflorus and V. szovitsiana (GGSc=1.000), and V. oxyrrhyncha (GGSc=0.883). The former groups contact with the latter group at the lowest level of resembling GGSc=0.417.
Table (5): Similarity matrix coefficient of cytological characters for Valerianaceae taxa.

| Cluster Analysis | UPGMA |
|------------------|-------|
| Importance data - Cytological data: Analyzing 6 variables (caryotypes) x 15 cases (species) |
| Gower General Similarity Coefficient | Similarity matrix |
| C. longiflorus | 1.00 |
| V. scabiosa | 0.500 | 1.000 |
| V. officinalis | 0.500 | 1.000 | 1.000 |
| V. caprifolium | 0.167 | 0.667 | 0.667 | 1.000 |
| V. carniolica | 0.333 | 0.833 | 0.833 | 0.500 | 1.000 |
| V. rosacea | 0.500 | 1.000 | 1.000 | 0.667 | 0.833 | 1.000 |
| V. coriacea | 0.167 | 0.667 | 0.667 | 1.000 | 0.500 | 0.667 | 1.000 |
| V. aucheri | 0.667 | 0.667 | 0.667 | 1.000 | 0.500 | 0.667 | 1.000 | 1.000 |
| V. densiflora | 0.500 | 1.000 | 1.000 | 0.667 | 0.833 | 1.000 | 0.667 | 0.667 | 1.000 |
| V. corniculata | 1.000 | 0.500 | 0.500 | 0.500 | 0.500 | 0.167 | 0.167 | 0.167 | 0.500 | 1.000 |
| V. thapsus | 0.667 | 0.833 | 0.833 | 0.200 | 0.667 | 0.833 | 0.500 | 0.500 | 0.833 | 0.667 | 1.000 |
| V. ephedra | 0.833 | 0.667 | 0.667 | 0.333 | 0.500 | 0.667 | 0.333 | 0.333 | 0.333 | 0.667 | 0.833 | 1.000 |
| V. decipiens | 0.500 | 1.000 | 1.000 | 0.667 | 0.833 | 1.000 | 0.667 | 0.667 | 1.000 | 0.500 | 0.500 | 0.500 | 1.000 |
| V. dioica | 0.167 | 0.667 | 0.667 | 1.000 | 0.500 | 0.667 | 1.000 | 0.667 | 0.167 | 0.500 | 0.500 | 0.500 | 1.000 |

4. DISCUSSION:

In the present study, the cluster analyzing based on the epitome of different morphological, palynological, anatomical and cytological characters. As mentioned by (Sneath and Sokal, 1973) and (Stuessy, 1990).

The computer cluster analyzing for the main characters of the family’s genera showed the distinct differences between Valerianella with Valeriana and Centranthus which they more similar in their characters than the Valerianella.

The dendrogram constructed from morphological characters, manifested morphologically the great similarity between the Valeriana species than the C. longiflorus, as well as this group has a single sister clade connected with the cluster of Valerianella species at the lower level. It seems these distances among them comes from the dissimilarity in duration, dense and types of indumenta, branching pattern, calyx modification, inflorescence type, number of stamens and ovary locules, fruit shapes, and habitat of growth, as (Aras et al., 2005) revealed that the existence of environmental and geographical groups with higher resemblances. The convergences among Valerianella species due to the similarity from habit, leaf type, indumenta types, branching and inflorescence pattern, and the divergences caused by dissimilarity from calyx tube shape and lobes number, and all fruits characters such as fruit shape, seed shape, and type of trichomes.
Dendrogram formed from pollen morphology showed some confusion among the family members. The species were divided into four similarity groups, three of them are similar at the GGSc=0.778 level, the convergence is a false synapomorphy caused by parallelism by the similarity in pollen size and polarity view. But the fourth group has the actual similarity at GGSc=0.889 and 0.833 level, the convergence due to the similarity in pollen shape, size and polarity.

Dendrogram constructed from anatomical characters showed the regular relationship among all taxa, the similarity and dissimilarity mostly caused by the internal characters. The divergence of V. szovitsiana due to the dissimilarity in epidermal tissue, stomata types and index, type of trichomes, ordinary cells, stem outline, leaf margin, and midrib outline. The species was a single taxon out of groups, meets other OTUs at a lower level of similarity GGSc=0.716. The other OTUs were divided into two groups; the first group has interpenetrated relationships among all other Valerianella species, where they are in different similarity levels, and the second group indicates the close relationship between both Valeriana species and C. longiflorus. These convergences due to the similarity of epidermal cells, absent or present the trichomes, the cross section outlines of stems, leaves, and fruits and occurrence of inulin similarities.

Dendrogram constructed from cytological karyotypic characters suggests the close relationship among all taxa at a high level of similarity. The convergences due to the equivalents of chromosome numbers for OTUs V. discoidea, V. vescicaria, V. coronata and V. pumila, and the occurrences of V. dufresnia, V. muricata, Va. sisymbriifolia and Va. alliarifolia, with V. szovitsiana and C. longiflorus, each group is similar at high level GGSc=1.000 in their groups. The clusters divergences of groups are caused by polyploidy appearance of the chromosomes.

5. CONCLUSIONS:

The current work demonstrated a fully supported relationship among studied genera and species of Valerianaceae family, and it has shown approximately a fair relationship between the species whether with their morphology and internal characters or even the environment they were distributed.

Conflict of Interest (1)

There is no conflict of interest.

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