

VEGETATION CLASSIFICATION ALONG HANNA LAKE, BALUCHISTAN USING ORDINATION TECHNIQUES

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Abstract

A survey of natural vegetation along Hanna Lake, Baluchistan was undertaken. The study was conducted with in two distinct zones for clear communities' demarcation. The vegetation data was analyzed by TWINSpan and DECORANA, to classify the vegetation into plant communities. Thirty eight species belonging to 16 families were recorded from 20 quadrats of Zone 1 and 36 species belonging to 16 families were recorded from 20 quadrats of Zone 2. Two major and four sub-communities were demarcated by TWINSpan in both zones. DCA results showed three distinct plant communities in both Zones. Mostly the TWINSpan and DCA results were similar and the plant communities classified by TWINSpan were confirmed by DCA. The study provided base line data, information and importance of native plant communities.

Introduction

A lake is a body of still water, lacking connection with sea, having land all around (Forel, 1901). According to Timms (1992), Lakes are bodies of water where plant does not project beyond the water surface. Lakes have their own lake system and create an environment suitable for ecosystem. The amount of water with in the lake depends upon the natural inputs because no stream drains the lake, usually. Natural inputs include rainfall, snowmelt and springs (Powers & Herridge, 2007). Two important features of a lake are its shape and depth. These two features and many other including climate, vegetation and soil affect the quality of water in the lake, which in turn affects the lake system and are a key determinant of water use and leisure potential of that lake. So there is a strong relationship between lake and shore land and upland vegetation (Frederick, 2002).

Soil around the lake affects the lake as it contributes nutrients and also controls the pace of runoff from the land into the lake. The characteristics of soil around the lake depend upon the water level with in the lake (Sideris, 2008). Vegetation along the lake plays an important role in the protection of water quality and poses an important check on soil erosion (Cooke, 2005). However, when soil and nutrients are driven to water, growth of algae and aquatic plants increases. This results in the depletion of dissolved oxygen for fish and other aquatic life and decreases the water quality (Stewart & Howell, 2003). Soil and vegetation relationship can be studied by multivariate or ordination techniques in which species are arranged along the gradients. Ordination techniques are commonly used in phytosociology. This may be done either by arranging the points along the axis or by forming the scatter diagram with two or more axis. Two Way Indicator Species Analysis (TWINSpan) is a classification technique, in which, there is a classification of stands and then this classification is used to achieve classification of species (Hill, 1979). Detrended Correspondence Analysis (DCA), an indirect gradient analysis technique in which the distribution of species is not controlled by environmental variables rather, it focuses to analyze the pattern of species distribution. Environmental data for DCA is not required and species data is used to assume the gradients (Sagers & Lyon, 1997).

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Ordination techniques are widely used by the ecologists to study the relationship between vegetation and environment. A study was conducted in Chott El Beida wetland, a RAMSAR site in Setif, Algeria to study distribution of plants community and environmental factors. The collection was done from sixty vegetation plots. TWINSpan and Detrended Correspondence Analysis (DCA) were used as the analysis techniques. 127 species belonging to 41 families and 114 genera were collected. They identified four main communities. This was greatly helpful to improve the baseline information on plant community (Khaznadar et al., 2009). A similar study was conducted along motorway (M-2), Pakistan using multivariate techniques i.e., TWINSpan and DECORANA. Results showed two major and sixteen sub-communities (divided by TWINSpan) from 397 quadrats and 227 plant species were recorded. The study was helpful for implementation and conservation planning and for the improvement of road sides (Ahmad *et al.*, 2010). To study the relationship between vegetation and environment, a study was conducted by He *et al.*, (2007) in the Alxa Plateau of Inner Mongolia, China. They collected 70 species representing 16 families and two-way indicator species analysis (TWINSpan) was used for classification which resulted in the detection of six characteristics vegetation groups. Vegetation and environmental parameters were studied by using the Detrended correspondence analysis (DCA) and canonical correspondence analysis (CCA). Jabeen and Ahmad (2009) conducted a study to analyze the vegetation and environment data of Ayub National Park, Rawalpindi. PC Ord 5 and CANOCO 4.5 were used and data was recorded by quadrat method. 44 plants species from 30 quadrats were recorded. Ahmad (2009) studied the herbaceous vegetation in Margalla Hills National Park, Islamabad, Pakistan. Study described the distribution and growth of plants. 52 herbaceous plant species belonging to 26 families were recorded in 30 quadrats. Four vegetation groups were recognized by TWINSpan. El-Bana *et al.*, (2009) studied *Juniperus phoenicea* L. (listed as threatened tree by IUCN Red List) and associated vegetation at three mountains, for the development of a conservation strategy in Egypt. TWINSpan and DCA analysis techniques resulted in the recognition of four vegetation types along with juniper.

Baluchistan lies between longitude 62 and 70 east and latitudes 25 and 32 north. It lies in the south west part of Pakistan and bounded by Arabian Sea in the south. Topographically Baluchistan consists of moderately high to high mountains and about 51.7% of area is classified as mountains (high and low). Present study was conducted to survey the area along Hanna Lake and to study the vegetation patterns and arrangement of plant communities. Baluchistan is the largest province of Pakistan with an area of 347,220 km². Hanna lake is located about 10 km east of Quetta at 30° 15' 0" N, 67° 6' 0" E. The surrounding area of Hanna Lake (study area) is semi mountainous. Total area covered by Hanna Lake is 27 acres. Hanna Lake rises in western slopes of Zarghoon range near Urak. Natural vegetation is so varied that study conducted on representative area can only be the source of information to understand the whole system. The specific objectives of present study include quantifying the vegetation along Hanna Lake using ordination techniques for future conservation and providing base line data of ecological important area.

Materials and Methods

For the clear communities demarcation study area along Hanna Lake can be divided into two zones. Zone 1 of study area was located about 500 m width along the Hanna Lake. Twenty quadrats were laid down along both sides (10 quadrats on each side). The

soil was comparatively affected due to presence of restaurant, huts, boating house, swings for children. Zone 2 of study area was located about 1000 m width along Hanna Lake. Similarly, from this zone, distribution of plant communities was recorded from 20 quadrats. The soil was less affected and sparse vegetation existed. Quadrat method was used for the collection of vegetation data. Quadrat size of $1 \times 1\text{m}^2$ was selected because mostly herbs and shrubs were present in the area. A 1m long tape was laid down to mark the quadrat of $1 \times 1\text{m}^2$. Quadrats were laid down randomly. Within each quadrat, cover values of plants were recorded by visual estimation according to Domin Cover Scale (Kent & Coker, 1992). Sampling was completed in April and May. The spring season starts in April, when most of the plants are in flowering stages. Species were identified and deposited in herbarium of Fatima Jinnah Women University, Rawalpindi and nomenclature was followed by Nasir & Rafiq (1995).

Results

TWINSPAN analysis was carried out for classification of plant communities using PC-ORD 5 which resulted in a two-way cluster dendrogram. Dendrogram was interpreted for two cut levels. A dendrogram is a hierarchical representation of species and stands in graphical form.

Zone 1: A total of 37 species belonging to 16 families were recorded from 20 stands of Zone 1 of study area (along 500 m width of Hanna Lake). Dendrogram classification of zone 1 (Fig. 1) divided the species into two major vegetation groups which were further divided into minor communities. Each community was named after the leading dominant species. Major Community 1 was named as *Andropogon-Alhagi* due to the highest presence of *Andropogon sp* and *Alhagi maurorum* species in the area. Major Community 2 was named as *Artemisia- Poa* due to the highest presence of *Artemisia sp* and *Poa sp*.

Community 1 was called *Alhagi-Centaurea* due to highest presence of *Alhagi maurorum* and *Centaurea iberica*. *Alhagi maurorum* was heavily-branched gray-green thicket with long spines along the branches. *Centaurea iberica* was a non woody herb. This group developed mostly near the water. The group occurred in 4 quadrats. Although these species were also present in other stands but the community was wide spread in stand no. 21, 25, 26 and 29. Stand no. 29 had the highest presence of these species. The total number of species in this group was 9.

Community 2 was called *Andropogon*. *Andropogon sp.*, was a grass wide spread in study area. It was recorded in almost every stand. Only three stands were devoid of *Andropogon sp.*, i.e. stand no. 01, 02 and 05. The species was present next to source of water, as well as over the hills, and in the middle of hills. TWINSPAN dendrogram showed this single specie forming a separate group.

Community 3 was called *Poa-Artemisia*, due the highest presence of *poa sp.* and *Artemisia sp.* *Poa sp.*, was a group of grass with smooth and hollow stem and grows in clusters. *Artemisia sp.*, was a branched, stiff, shrubby plant with very small leaves and yellowish flowers. It was the largest community separated by TWINSPAN clustering. Species were recorded from stand no. 1, 2, 4, 5, 23, 24, 27, 30. These stands were recorded from the semi mountainous area. Community was wide spread over the middle of hills. Total number of species in the community was about 25.

Community 4 was called *Eryngium-Astragalus*. *Eryngium sp.*, had very sharp spiky leaves. *Astragalus sp.*, was a thorny plant. The community was wide spread in stand no. 4, 5, 21, 23. In stand no. 21 and 23, these species were recorded with an abundance of more than 10%. *Eryngium sp.*, was also present in other stands. The community was found over the hills and stands were recorded from semi mountainous area. Total number of species in this community was 5.

Zone 2: A total of 36 species were recorded from 20 stands in Zone 2 of study area (along 1000m width of Hanna Lake). Similar classification of Dendrogram resulted in two major vegetation types which were further divided into minor communities and sub-minor communities. Each community was named after the leading dominant species. Major Community 1 was named as *Achillea-Taraxacum* due to the highest presence of *Achillea santolina* and *Taraxacum officinale* species in the area (Fig. 2). Major Community 2 was named as *Artemisia-Andropogon* due to the highest presence of *Artemisia sp.*, and *Andropogon sp.*, Minor communities were:

Community 1 was called *Achillea-Taraxacum* due to the presence of *Achillea santolina* and *Taraxacum officinale*. *Achillea santolina* had hairy leaves and flat clusters of small flowers at the top of the stem. *Taraxacum officinale* was a common weed consisting of more than 1 stem that produce flower head. Community was present in two stands i.e. stand no. 32 and 34. These stands were recorded from an area near the road. Total number of species in the community was four.

Community 2 was called *Centaurea-Teucrium* due to the presence of *Centaurea iberica* and *Teucrium stocksianum*. *Centaurea iberica* is a weed with rosette leaves and spines. *Teucrium stocksianum* was a herb having anti-inflammatory properties. Community was present in stand no. 33 which was recorded on the slope of mountain. Total number of species in this community was four.

Community 3 was called *Andropogon-Saussoria*, due to the presence of *Andropogon sp.*, and *Saussoria sp.*, *Andropogon sp.*, is a grass wide spread in study area *Eryngium sp.* had very sharp spiky leaves. It was relatively large community with 22 species. Community was widespread in stand no. 12, 37, 38 and 40. The stands were recorded over the hills.

Community 4 was called *Poa-Artemisia*, due the highest presence of *Poa sp.*, and *Artemisia sp.* *Poa sp.*, is a group of grass with smooth and hollow stem and grows in clusters. *Artemisia sp.*, is a branched, stiff, shrubby plant with very small leaves and yellowish flowers. These species were present more than 10% in stand no. 15 and 35. These stands were recorded from the semi mountainous area. Community was recorded from stand no. 15, 20, 33, 35, 36, 37, 38, and 39. Community was wide spread over the middle of hills. Total number of species in the community was six.

DCA analysis of vegetation: Detrended Correspondence Analysis (DCA) was performed for the further classification of species. It was used to study the pattern of specie distribution and major plant communities with in the study area and to verify the results of TWINSpan analysis. Default values of PC-Ord ver 5 were used and DCA analysis resulted in AX1 and AX2 value from which ordination diagram was constructed. Each point on the graph corresponded to species. The different species occurring with exactly the same abundances in the same quadrat would occupy the same point. The distances between points on the graph represented the distribution of species.

Zone 1 Ordination diagram (Fig. 3) of 20 quadrats analyzed of Zone-1(stand no.1-10 and stand no. 21-30) resulted in three communities representing 38 species. Three plant communities were indicated by Group 1, Group 2 and Group 3.

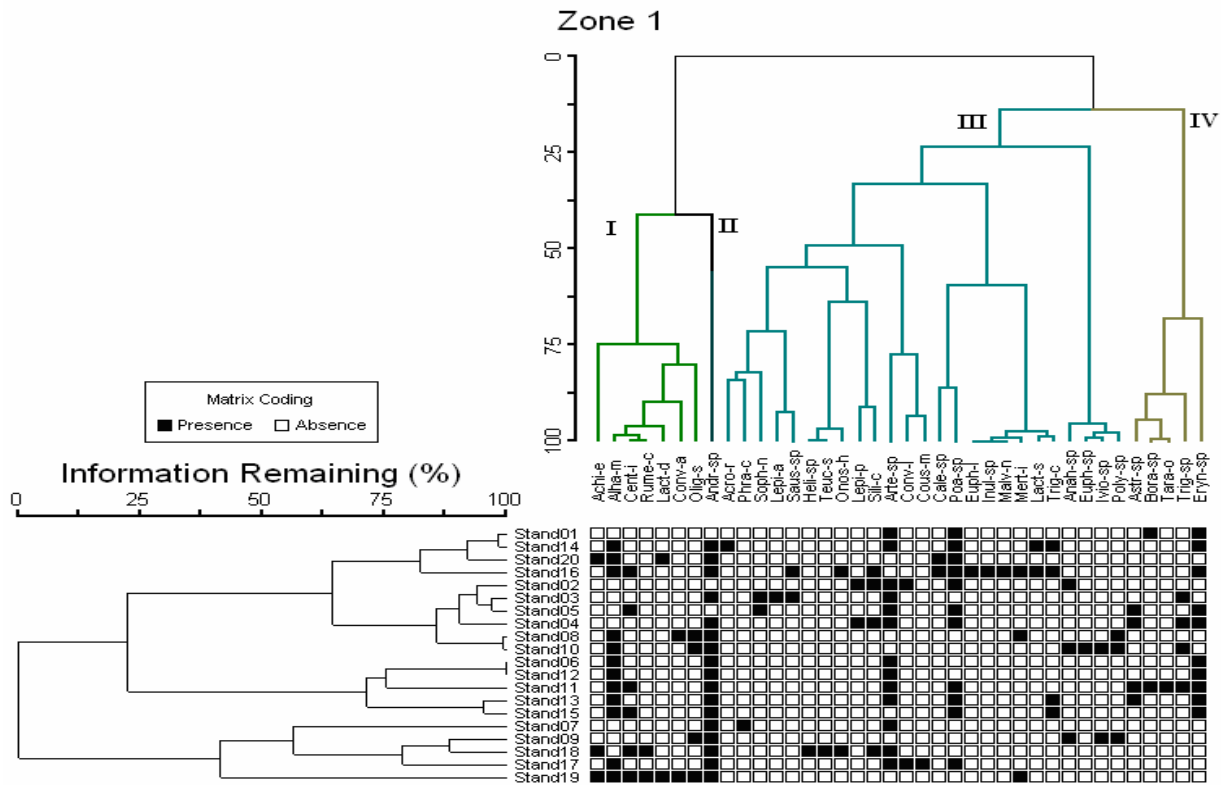


Fig. 1. Zone 1: Two Way Cluster Dendrogram of species and quadrats.

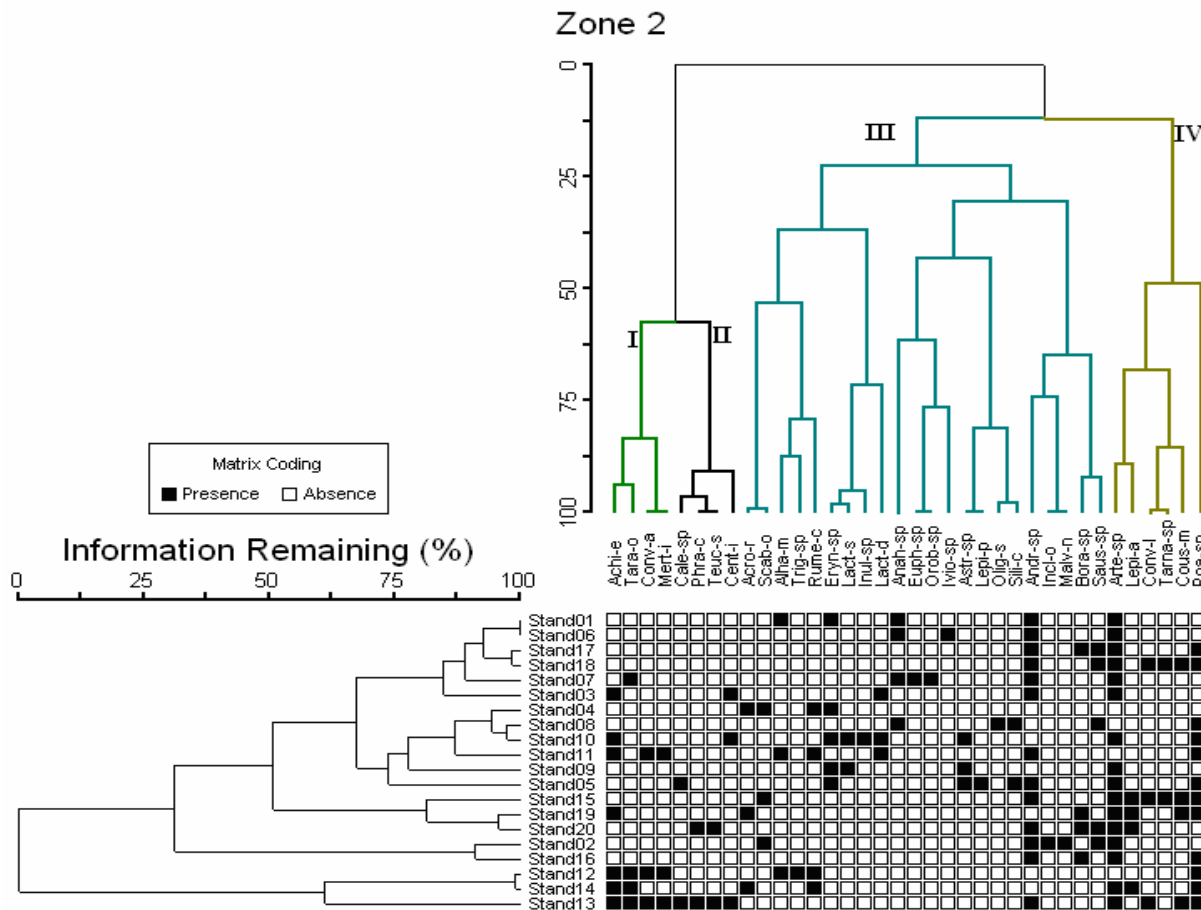


Fig. 2. Zone 2: Two way cluster Dendrogram of species and quadrats.

Group 1 was named *Alhagi-Centaurea* due to highest presence of *Alhagi maurorum* and *Centaurea iberica*. Species present in this group include *Achillea santolina*, *Boraga sp.*, *Calendula sp.*, *Convolvulus arvensis*, *Heliotropium sp.*, *Lactuca dissecta*, *Hertia intermedia*, *Onosma hispidis*, *Rumex chalepensis* and *Teucrium stocksianum*. This group grew in the area that was comparatively close to water. *Alhagi maurorum* is also called camelthorn, which is a green herbaceous shrub with thorny branches.

Group 2 was called *Poa-Artemisia*, due the highest presence of *poa sp.*, and *Artemisia sp.* Other species present in this group are *Acroptilon repens*, *Astragalus sp.*, *Boraga sp.*, *Eryngium sp.*, *Euphorbia linifolia*, *Inula sp.*, *Lactuca serriola*, *Lepidium apetalum*, *Malva neglecta*, *Saussurea sp.*, *Taraxacum officinale*, *Trigonella calliceras* and *Trigonella sp.* The group was present over the semi mountainous area, in the middle of hills. *Poa sp.*, is a persistent grass, with smooth and hollow stem.

Group 3 was called *Andropogon*, due to the presence of *Andropogon sp.*, in the study area. *Andropogon* specie was present in almost every stand and only 3 stands were devoid of *Andropogon* specie. Moreover TWINSPAN result of Zone 1 also indicated the single specie as a separate group. *Andropogon sp.*, is a grass of family Poaceae.

Zone 2 Ordination diagram (Fig. 4) showed the distribution of plants in zone 2 (stand no.11-20 and stand no. 31-40) of study area. 20 quadrats were analyzed and 36 species were recorded. Similarly three plant communities in this zone were indicated by Group1, Group2 and Group 3.

Group 1 was called *Andropogon- Saussurea* due to the highest presence of *Andropogon sp.*, and *Saussurea sp.* Other species in this community were *Anaphalis sp.*, *Euphorbia sp.*, *Orobancha sp.*, *Ixiolirion sp.*, *Inula sp.*, *Malva neglecta*, *Boraga sp.*, and *Saussurea sp.* The group was present over the hills. *Andropogon sp.*, formed the understory in association with other species. *Andropogon sp.*, was present in most of the stands in this group. Other dominating species was *Saussurea sp.* Among other species most common was *Boraga sp.*

Group 2 was called *Eryngium-Astragalus* due to the dominationg presence of *Eryngium sp.*, and *Astragalus sp.*, other species in this group were *Lactuca serriola*, *Lepidium pinnatifidum*, *Silina canaider*, *Alhagi maurorum*, *Lactuca dissecta* and *Calendula sp.* *Eryngium sp.*, is a perennials for dry soil and grows in dry and sunny habitat. *Astragalus sp.*, is toxic specie which is toxic to live stock. It forms the community in the wetlands, also capable to grow in dry areas.

Group 3 of Zone 2 was called *Poa-Artemisia*, due the highest presence of *Poa sp.*, and *Artemisia sp.* Other species present in this group are *Taraxacum officinale*, *Convolvulus arvensis*, *Hertia intermedia*, *Artemisia sp.*, *Phragmites carper*, *Achillea santolina*, *Oligochaeta ramose*, *Teucrium stocksianum*, *Scabiosa olivieri*, *Lepidium apetalum*, *convolvulus lineatus* and *Cousinia minuta*. *Poa sp.*, is a persistent grass, with smooth and hollow stem Among other species most common was *Achillea santolina*. *Achillea santolina*.

Discussion

Hanna Lake is a popular weekend place. It is a small lake that is surrounded by Hills. It is an important place for tourism (Singh, 2004). Present study examined the species distribution along Hanna Lake. A total of 38 species were recorded from zone 1 and 36 species were recorded from zone 2. These plants belonged to 16 families. There was sparse vegetation in the study area and vegetation was present in patches. Most of Plant ecologists have tried to quantify the distribution of plant species along the environmental gradients. There is a correlation between vegetation pattern and resources available (Whittaker, 1956; Smith & Huston, 1989; Ahmad *et al.*, 2009 and Jabeen & Ahmad, 2009).

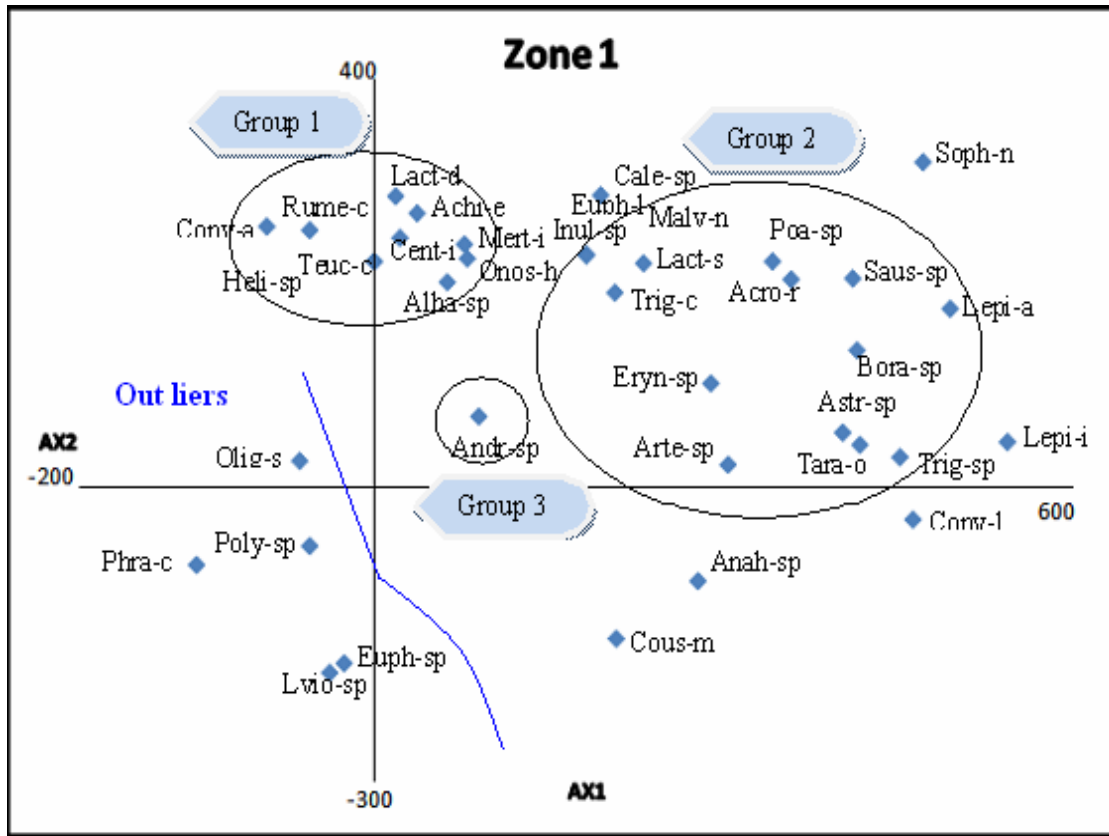


Fig. 3. Ordination diagram of description of plant communities and out liars of Zone 1 of study area as demarcated by DCA.

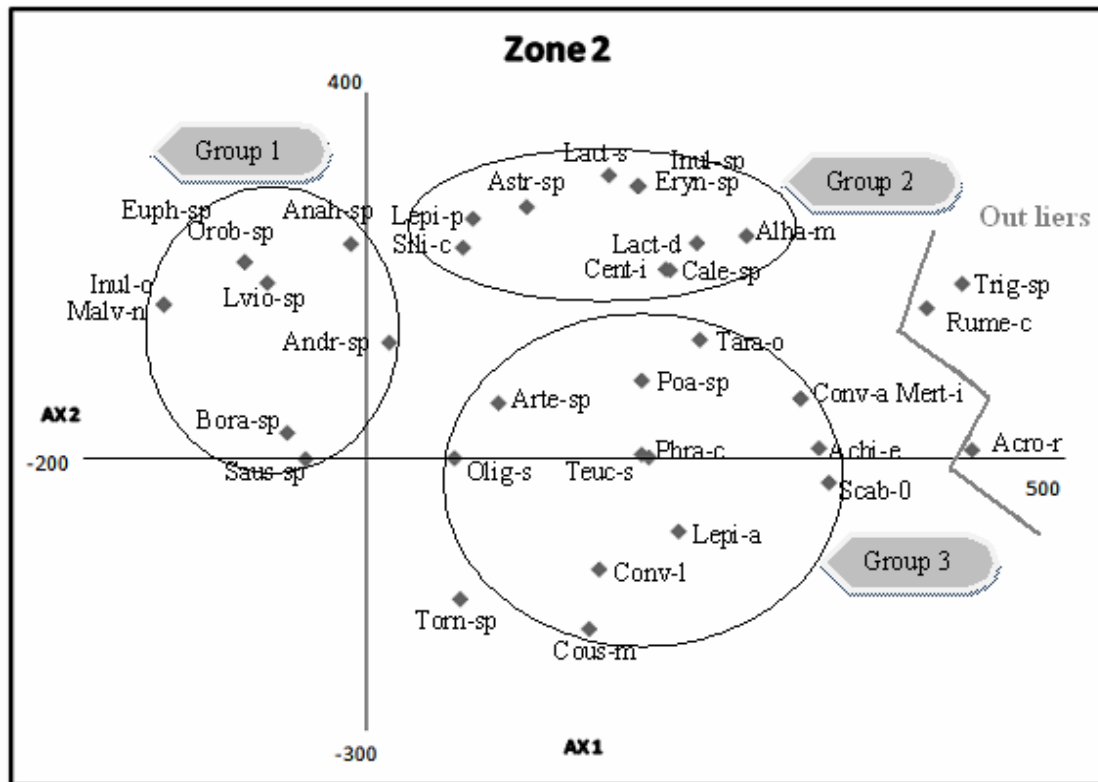


Fig. 4. Ordination diagram of description of plant communities and outliers of Zone 2 of study area as demarcated by DCA.

TWINSPAN was applied for general classification of species which resulted in a two way cluster Dendrogram. TWINSPAN divided Zone 1 and Zone 2 into two major groups, which were further divided into minor groups. It indicated the frequency of different species and compared their abundance. Four communities from Zone 1 and four communities from Zone 2 were focused by the present study. El-Ghanim *et al.*, (2010) studied the vegetation at Hail region north of central Saudi Arabia where TWINSPAN results showed 7 vegetation groups. Ahmad *et al.*, (2010) analyzed the vegetation along motorway (M-2), Pakistan by using multivariate techniques. TWINSPAN results showed 16 communities. DCA Ordination diagram described the specie distribution and major plant communities with in study area. Mostly the communities described by the TWINSPAN were confirmed by DCA ordination diagram.

In Zone 1 community was named *Alhagi-Centaurea* due to highest presence of *Alhagi maurorum* and *Centaurea iberica*. The group grew close to water. The reason of wide spread of *Alhagi maurorum* is that it has ability to change its form with changing environmental conditions. For instance, when there are moist conditions thorns are less in number and leaves are larger, but when the conditions become worse, leaves are smaller and thorn are large in number (DiTomaso, 2007). In the study area, the plant was present near water source, but the soil was dry and it had more thorns and few and small leaves. Another reason for the widespread of this plant might be that population spread by seeds and rhizomes and it is irritating to animals. Root system is widely crawling and grows horizontally making it possible to grow in dry areas (DiTomaso, 2007). *Centaurea iberica* is classified as a “noxious weed” (Anonymous, 2009). It requires well-drained soil and can grow in nutritionally poor soil. In Zone 2, community showed the presence of *Centaurea iberica* as associated specie and the dominant species were *Eryngium sp.* and *Astragalus sp.*, forming the community *Eryngium-Astragalus*. *Astragalus sp.* reproduce by seeds which are long lived and is scarce in dry period and abundant in wet period (DiTomaso, 2007) *Eryngium sp.* grows in dry and moderate habitat (Tatroe and Mann, 2007). As sampling was done in April and May, when there was very less rainfall and the conditions were dry.

Poa-Artemisia was another community of Zone 1 which was named after the highest presence of *Poa sp.*, and *Artemisia sp.* The community was found over the semi mountainous area with 13 other species. *Poa sp.*, can dominate in the area by competing with other species (Novak & Welfley, 1997). *Artemisia sp.*, belongs to xerophytes, which can tolerate dry periods. It copes with the changing conditions in a way that in the start of dry period it has large hairy leaves. When the dry period arrives newly formed leaves are smaller and with more hairs. When the conditions are worse, large and small leaves die and only shoot tip remains (Prasad, 1997). *Artemisia sp.*, can play a great role in renewal programs of agriculture; it is helpful in the management of arid regions of the world (Wright, 2002). Among other species *Astragalus sp.*, was common species. *Astragalus sp.*, reproduce by seeds which are long lived and is scarce in dry period and abundant in wet period (DiTomaso, 2007). According to Rodwell & Pigott (2000) *Poa sp.*, forms community with *Taraxacum officinale* at garden soil, grass land, waste grounds. In Zone 2 similar community was found with *Poa sp.*, and *Artemisia sp.* as dominant specie. But the associated species forming the community were different except *Taraxacum officinale*. Here *Achillea santolina* was other common specie. *Achillea santolina* becomes dominant in the area where there is less rainfall and area is dry (Zahran, 2010).

Community 3 of Zone 1 was called *Andropogon*, due to the dominance of *Andropogon* sp., TWINSpan results also showed it as separate group. According to Burk (2005), *Andropogon* sp., is an important and dominating plant forming the understory. There are different plants that form the understory and competition lies between those plants. Such a competition is dominated by grasses like *Andropogon* sp. An other reason of widespread of *Andropogon* sp. is that it becomes dominant specie on the poor soils. In Zone 2 TWINSpan and DCA results showed *Andropogon* sp. forming community with other species like *Sausseria* sp. *Sausseria* sp., typically grows in arid and dry climate present in the scattered form (Chadha, 1990).

The present study highlighted the importance and conservation of native flora and few medicinally important species in the study area. This base line data can be used to start comprehensive species classification in whole area.

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