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IMPACT OF HIGHLY SALINE WETLAND ECOSYSTEM ON FLORAL DIVERSITY OF THE CHOLISTAN DESERT

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Abstract

The impact of highly saline wetland ecosystem created under Salinity Control and Reclamation Project (SCARP) on floral diversity was investigated in the arid environments of Cholistan Desert. Species richness, diversity indices and evenness indices were worked out to look at the distance at which the salt water has altered the native vegetation. Four sites including SCARP ponds of different ages (S_1, S_2, S_3 and S_4), and a reference site (S_R) were selected for vegetation studies and data were recorded by 1x1 m quadrats, which were laid on permanent transect lines. Salt water showed great influence on ecological parameters of the native vegetation up to 40 m. Multivariate (cluster) analysis showed close clustering of highly salt tolerant species, *Aeluropus lagopoides*, *Tamarix dioica* and *Suaeda fruticosa* in one group, and relatively less tolerant *Crotalaria burhia, Cyperus conglomeratus, Indigofera argentea, Haloxylon salicornicum, Haloxylon stocksii, Neurada procumbens* and *Salsola baryosma* in second group. Moderately salt tolerant *Aristida adscensionis, Lasiurus scindicus* and *Sporobolus iocladus* were clustered in a separate group.

Introduction

Wetlands are among the important and productive ecosystems of the world, occupying about 6% of the earth's surface (Maltby, 1983). Wetlands have been drained, customized, or shaped to produce or enhance agricultural crops. This degradation poses considerable effect on wildlife numbers, water quality, hydrological cycles and other wetland functions and values. Wetlands are the important breeding centres for many waterfowl species. Natural wetlands are in decline throughout the world as the human population keeps growing (Prasad, 2010).

The land resources of Pakistan are becoming limited. Responding to the rising demands of ever-increasing human population for food and fiber, marginal lands are being cultivated on the one hand and the prime agricultural land is being eroded on the other hand. To reclaim the waterlogged and salt affected agricultural lands, Salinity Control and Reclamation Project (SCARP) was planned and implemented with the assistance of the World Bank and some other donor agencies (Anon., 1998) in the Cholistan desert.

The vegetation of Cholistan desert is a typical of arid regions, which comprises xerophytic species, adapted to extreme seasonal temperature, moisture fluctuation and a wide variety of edaphic conditions (Hameed *et al*., 2011). Vegetation cover is comparatively better in the eastern region (200 mm rainfall zone) than that in the hyper-arid southern region (100 mm rainfall zone). The soil topography and chemical composition is playing an important role in plant distribution in the area. The association of certain plant species to certain soils at different places is very common. The compact saline 'dahars' without any soil cover are dominated by *Haloxylon recurvum, Haloxylon salicornicum, Suaeda fruticosa Sporobolus ioclados, Aeluropus lagopoides,* and *Salsola baryosma,* whereas, *Capparis decidua, Cymbopogon jwarancusa, Ochthochloa compressa* and *Prosopis cineraria* are specific to the 'dahars' having some sandy cover (Naz *et al*., 2010a, b, c). Similarly, the sand dunes are dominated by *Calligonum polygonoides, Aerva javanica, Panicum turgidum* and *Lasiurus scindicus* (Rao *et al*., 1989; Arshad *et al*., 1994; Arshad & Akbar, 2002). A variety of dominant plant species and soil types are found within the Cholistan desert (Arshad *et al.,* 2007).

The present study was conducted to find out the effect of SCARP ponds on the distribution pattern of vegetation in the adjoining areas within the Cholistan desert, which would assist in the management/restoration of natural vegetation in the desert.

Material and Methods

The study area: The Cholistan desert is situated in the South-West of Punjab province (Pakistan) and is spread over an area of 26,000 km^2 with patches of highly saline soils and brackish sub-soil aquifer or water. It is located between latitudes of 27° to 42° and 29°N and longitudes of 57° to 60°E. The length of the desert is about 480 km and breadth is from 32 to 192 km (Akbar *et al*., 1996). The average rainfall is 180 mm but it may be as low as 2 mm. The peak rainy months are July and August with the rainfall ranging from 38 to 56 mm. Thus, the area is least influenced by summer monsoon and in most parts of the year it remains short of water. Droughts in this region are quite common, sometimes extending from 2 to 3 years, causing a lot of harms (Chaudhry & Nasim, 1995).

Cholistan desert, once used to be a prosperous, lively and thriving forest, is now by and large a deserted piece of land. It is a very typical rangeland and contributes significantly towards country's supply line for live animals and their products (milk and meat), but now its productive potential is on the decline in spite of the fact that the number of animals in the desert is on the increase, whereas its bioresources are on the decrease (Ahmad, 2005).

Vegetation survey: Various methods were adopted to collect and analyze the data on different aspects. The vegetation around the study ponds (sites: S_1, S_2, S_3, S_4, and the reference site S_R) was sampled on three transects laid perpendicular to shore-line of each of the four study ponds. A main rectangular quadrat of 1 x 5 m (each having five 1 x 1 m sub- quadrats) were used to sample vegetation on each point of transect lines. Twenty main-quadrates were placed along each of the transects at the distances of, 0, 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 130, 150, 170, 190, 210, 230 and 250 m from the pond water as per layout (Fig. 1). The parameters like, number of plants, number of plants belonging to each species and percent vegetation cover contributed by each species were recorded for each plant species falling in the quadrats. The data collected during this study were analyzed using Microsoft Excel 2000, Minitab 11 for Windows, Jandel Scientific's SigmaStat 2.0, EstimateS 5.0.1 and the GWBASIC Programs (Ludwig & James, 1988). Hussain (1983) was consulted for choosing the appropriate formulae for the estimation of various quantitative parameters such as, abundance and incidence-based species richness (SR), evenness indices (E1 and E2), Shannon's index (H') and Simpson's index (λ).

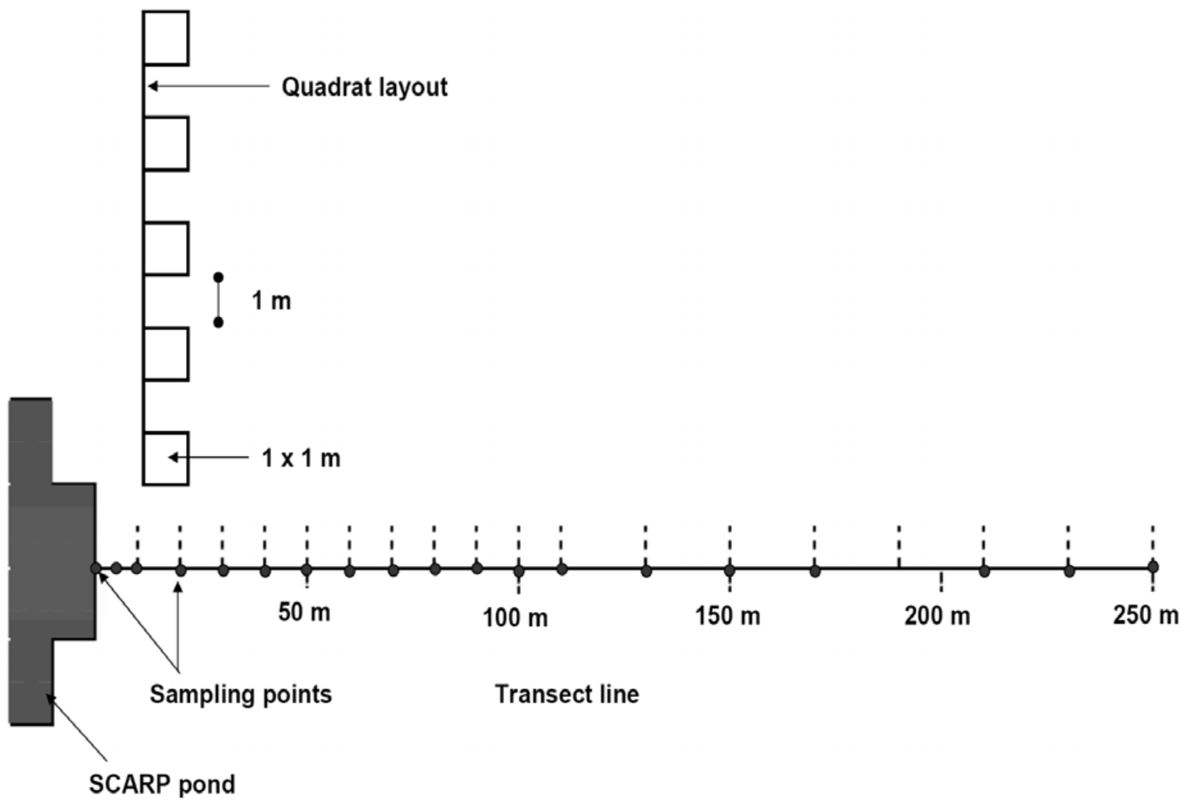

Fig. 1. Layout of the vegetation sampling quadrats on a transect line.

Results and Discussion

Vegetation near the study ponds: The man-made ecological changes usually have a profound effect on the plant communities of an area. The creation and operation of the evaporation ponds under a drainage project along the margin of the Cholistan Desert may have triggered ecological changes in the flora of the study area. A total of 27 plants were recorded (18 dicots and 9 monocots), which belonged to 25 genera from 14 families (Table 1). The family with the highest number of species was Poaceae (8 spp.), followed by Chenopodiaceae (4 spp.), and Asclepiadaceae and Papilionaceae (2 spp. each). The diversity of growth forms among the recorded species was high, including shrubs with photosynthetic stems (e.g., *Calligonum polygonoides*, *Leptadenia pyrotechnica*, *Haloxylon salicornicum*), xero-halophytic semi-shrubs (e.g., *Suaeda fruticosa*), succulents with milky sap (e.g., *Calotropis procera*) thorny shrub/trees (e.g., *Prosopis cineraria*), shrubs adapted to extreme dryness (e.g., *Aerva javanica*), and perennial grasses (e.g., *Stipagrostis plumosa, Sporobolus ioclados* and *Cymbopogon jwarancusa*). The number of plant species recorded from the four study sites viz. S_1, S_2, S_3 and S_4 was 18, 18, 12 and 12, respectively, while from reference site (S_R) 16. Of the 27 plant species, 20 recorded from the five sites were dominant or co-dominant in different plant communities at different locations (Table 1). At the community level, the species differed in their response to the changes brought about in the habitat by the succession (as it existed in the SCARP habitat) and can cause changes in the relative abundance, community composition and species diversity (Elmberg *et al*., 1993).

Table 1. Record of plant species at four SCARP pond sites and one reference site in Rahim Yar Khan district of the Punja.

Species	Site 1	Site 2	Site 3	Site 4	Site (Ref)
Aerva javanica (Amaranthaceae)	+	+	+	+	+
Aeluropus lagopoides (Poaceae)	+	+	+	-	+
Aristida adscensionis (Poaceae)	-	-	-	+	-
Calligonum polygonoides (Polygonaceae)	+	+	+	+	+
Calotropis procera (Asclepiadaceae)	+	-	-	-	+
Cenchrus ciliaris (Poaceae)	+	+	-	-	-
Crotalaria burhia (Papilionaceae)	-	+	-	-	+
Cymbopogon jwarancusa (Poaceae)	-	-	-	-	+
Cyperus conglomerates (Cyperaceae)	+	+	-	-	-
Dipterygium glaucum (Capparidaceae)	+	+	+	+	+
Euphorbia prostrate (Euphorbiaceae)	+	+	-	-	-
Fagonia indica (Zygophyllaceae)	-	+	-	-	-
Haloxylon stocksii (Chenopodiaceae)	-	-	-	-	+
Haloxylon salicornicum (Chenopodiaceae)	+	+	+	+	+
lndigofera argentea (Papilionaceae)	-	+	-	-	-
Lasiurus scindicus (Poaceae)	+	-	+	+	+
Leptadenia pyrotechnica (Asclepiadaceae)	+	+	+	+	-
Mollugo cerviana (Molluginaceae)	+	-	-	-	+
Neurada procumbens (Neuradaceae)	-	+	-	-	-
Ochthochloa compressa (Poaceae)	+	+	+	-	-
Prosopis cineraria (Mimosaceae)	-	+	-	-	-
Salsola imbricata (Chenopodiaceae)	+	-	-	+	+
Sporobolus iocladus (Poaceae)	-	-	-	-	+
Stipagrostis plumosa (Poaceae)	+	-	+	+	+
Sueada fruticosa (Chenopodiaceae)	+	+	+	+	+
Tamarix aphylla (Tamaricaceae)	+	+	+	+	-
Tamarix dioica (Tamaricaceae)	+	+	+	+	+
Total species recorded on the site	**18**	**18**	**12**	**12**	**16**

The plant abundance data from 1 x 1 m sub-quardats (5 sub-quadrats taken for each 1 x 5 m rectangular quadrat at each sampling point on each of the three transects at each site) was used to estimate richness indices for the plant communities at varying distances from the study ponds (Colwell, 2007). The abundance and incidence-based species richness (Chazdon *et al.*, 1998; Chao *et al*., 2000) for the plant communities occurring around the four SCARP sites at various distances from the pond shore were compared (Figs. 2a and 2b). S_1 and S_2 were different with respect to the distribution of species richness from S_3, S_4 and S_R. The area surrounding S_1 pond was richest in plant species followed by S_2 as compared to the areas surrounding S_3 and S_4 ponds and the reference site (S_R). In general, at S_3 and S_4, both richness indices attained their peak values at distances of 20-25 m from the pond, whereas they reached their peaks at distances of 100-200 m at S_2 and S_1, respectively. Comparison of richness curves from the two estimations showed that both estimates tended to converge with increased number of samples. The abrupt decrease in species richness at S_3 near farther end of transects, which is analogous to what has been earlier observed elsewhere (Sergio & Pedrini, 2007).

Figs. 2c & 2d compare the Simpson and Shannon diversity indices for the plant communities at varying distances around the four study ponds, S_1-S_4 and at the reference site (S_R). As per Simpson's diversity index the plant communities surrounding S_4 are most diverse followed in order by S_1, S_2 and S_3, whereas the diversity at the reference site fell between S_1 and S_4 (Fig. 2c). On the other hand, with respect to the Shannon's diversity index, S_1 and S_4 were similar in diversity of plant communities followed by S_2 and S_3 and the diversity of plant communities at the reference site (S_R) was comparable to that with sites S_1 and S_4. The Simpson's diversity index for plant community suddenly increased with increase in distance from the pond shore up to distances of 30-40 m, whereas the Shannon's index showed a relatively steady increase up to distances of about 100 m for almost all sites.

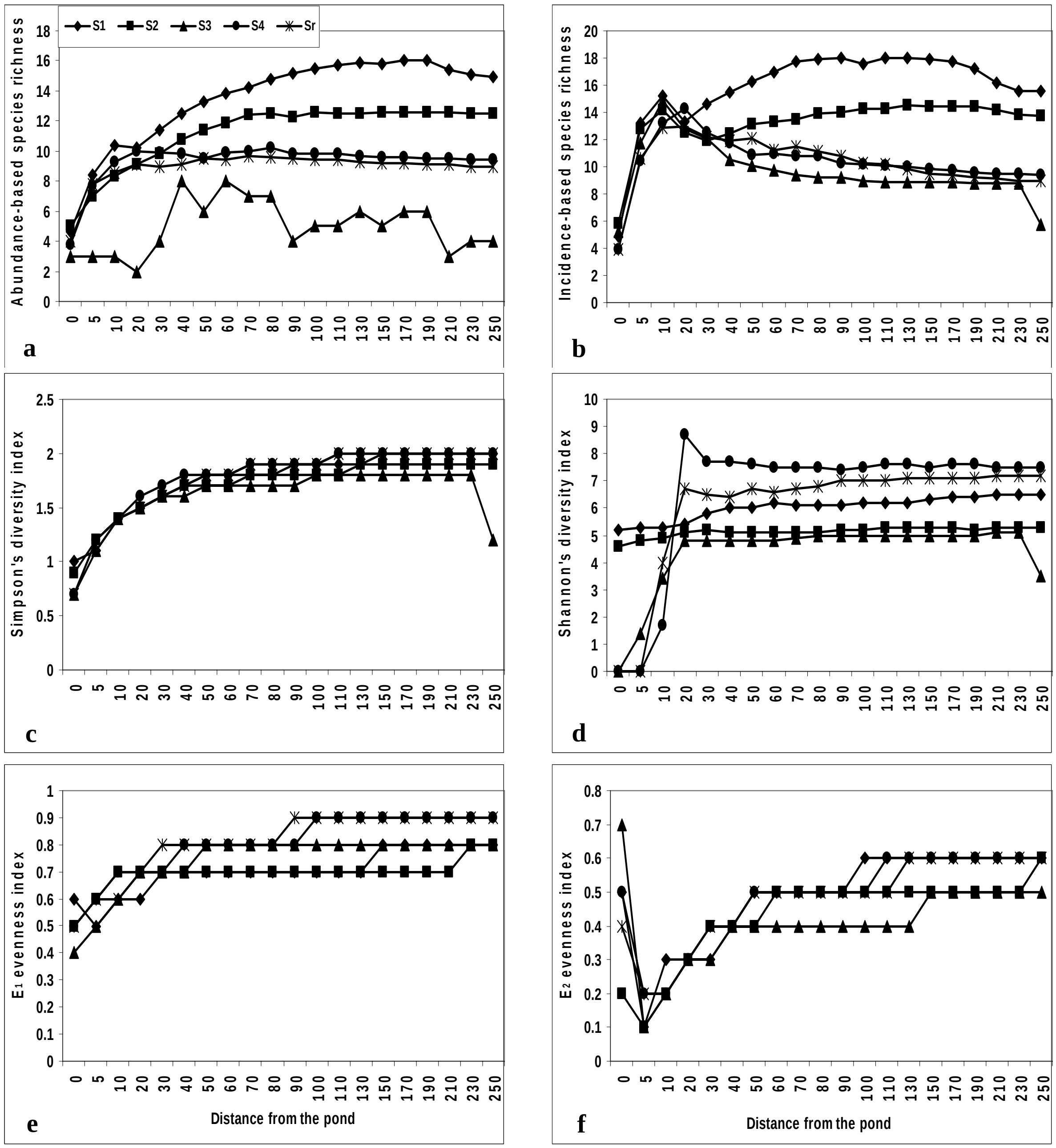

Fig. 2. Species richness, diversity indices and evenness indices of species diversity studied at SCARP sites, S1, S2, S3, S4 and at reference site Sr.

The evenness index (E1) presented in Figs. 2e & 2f showed a step-wise increase with the increasing distances from the study ponds and E2 attained very high values at the pond shore, dropped to its minimum values near the shore and then showed a consistent increase similar to that of E1. With almost pure community of *Tamarix dioica* bordering the SCARP ponds, the increasing pattern shown by the evenness index E2 may be regarded as better representative of the actual situation at the study sites. From the comparison of Figs. 2e & 2f it can be concluded that around the SCARP ponds at the distances nearer to the ponds the plant communities were more even at S_4 as compared to those at S_1 and S_2, and the plant community around S_3 showed values in between these two, whereas the evenness of the plant communities at the reference site was comparable to that of S_4.

Multivariate (cluster) analysis showed a close clustering of three species, *Aeluropus lagopoides*, *Tamarix dioica* and *Suaeda fruticosa* in group (iv); all of these species are highly salt tolerant (Naz *et al*., 2009). In group (iii), *Crotalaria burhia, Cyperus conglomeratus, Indigofera argentea, Haloxylon salicornicum, Haloxylon stocksii, Neurada procumbens* and *Salsola baryosma* were found with close association and all of them dominated saline inter-dunal areas (Hameed *et al*., 2011). In group (ii), *Aristida adscensionis, Lasiurus scindicus* and *Sporobolus iocladus* were in close clusters and all being moderately salt tolerant (Naz *et al*., 2010b). In group (i), all the species preferred sandy soils except for *Suaeda fruticosa*, which is a halophyte and its appearance in this community, might have been due to the accumulation of salts in the area with the establishment of SCARP evaporation ponds.

Ecological parameters of the native vegetation showed a strong alteration in the area indicated by the development of a thick *Tamarix dioica* ring fringing the evaporation ponds. Plant communities on the sand dunes were found to be less affected. The water supply to the ponds needs to be ensured for healthy ecological functioning of this wetland habitat in long-term. The results showed marked relationships between soil characteristics and plant species. *Suaeda fruticosa* and *Haloxylon recurvum* were found on higher salinity levels and low organic matter. *Calligonum polygonoides, Aerva javanica, Dipterygium glaucum, Capparis deciduas* and *Haloxylon salicornicum* were recorded on sites with slightly higher organic matter and low salinities. Ecological characteristics, responsible for plant distribution in the Cholistan desert seem to be salinity, organic matter and ionic concentration.

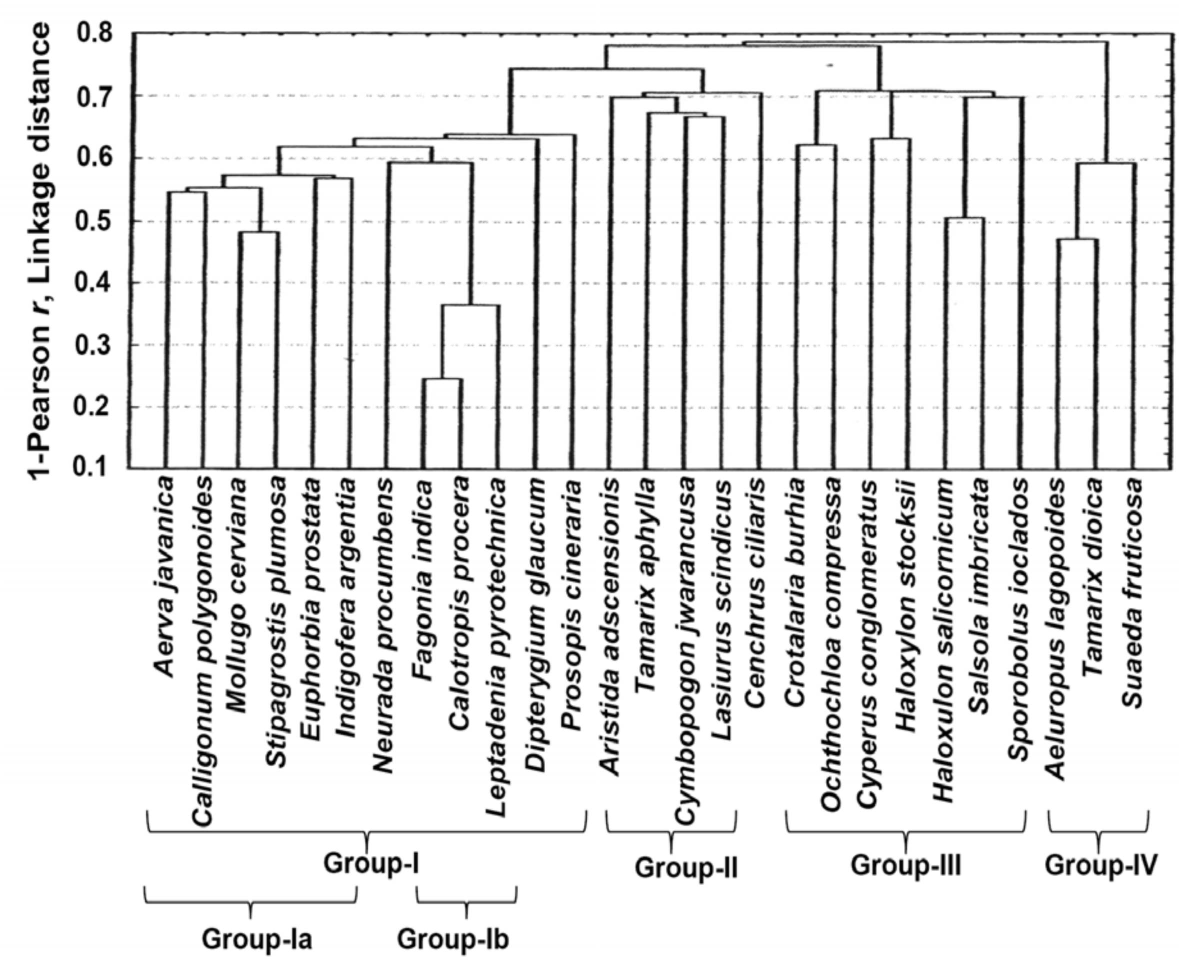

Fig. 3. Dendrogram of plant species recorded at SCARP ponds based on importance value of using single linkage Pearson's method.

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