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IMPACT OF SALINITY ON SPECIES ASSOCIATION AND PHYTOSOCIOLOGY OF HALOPHYTIC PLANT COMMUNITIES IN THE CHOLISTAN DESERT, PAKISTAN

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Abstract

Five distinct habitats in the Cholistan desert were explored for phytoecological attributes and species association. Community structure and distributional pattern of the species was mainly dependent on the salinity gradient. Relatively more salt tolerant species viz., *Sporobolus ioclados* with *Aeluropus lagopoides, Haloxylon recurvum* and *Suaeda fruticosa* were the dominant components of highly saline sites, whereas, moderately saline habitats supported less tolerant species *Fagonia indica, Cymbopogon jwarancusa* and *Ochthochloa compressa.* The distributional pattern of individual species was affected by the salinity level of the habitats. The association of the species was dependent on the degree of salinity tolerance of individual species. Relatively high salt tolerant species like *A. lagopoides, S. ioclados, S. fruticosa,* and *H. recurvum,* showed a broad range of association as compared to the moderately salt tolerant species.

Introduction

In Pakistan, Cholistan represents a vast desert spreading over about 26,000 km^2 in the South Punjab, Pakistan, which is an independent bioregion of its own nature. The flora is typically xeric confronted with multiple stresses. Besides trampling and overgrazing the life is exposed to harsh conditions of high temperature, drought, salinity and sodicity (Arshad *et al*., 2008). Despite adverse environmental conditions, Cholistan has a diverse vegetation including grasses, herbs, shrubs and trees (Rao & Baber, 1990; Hameed *et al*., 2002; Naz *et al*., 2010).

Geographically, Cholistan is divided into lesser and greater regions. These regions are divided into four habitat types viz., sand dunes, sandy plains, compact soils with gravels and saline areas (Hameed *et al*., 2002). Each site depicts a typical plant community with xeric and halophytic morphogenetic adaptations (Akbar *et al*., 1996, Arshad *et al*., 2008). The dominant vegetation component of halophytic communities in the saline area of the Cholistan comprises dicot species of the genera like *Tamarix, Haloxylon, Suaeda,* and *Salsola,* whereas monocots like *Aeluropus, Sporobolus, Ochthochloa* and *Cymbopogon* (Naz *et al*., 2009). The soils are dark gray brown to blackish in color, severely saline in nature and very poor in fertility with a pH ranging from 8.0-9.0 (Arshad & Akbar, 2002).

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Saline habitats, especially in the deserts are characterized by specific plant communities (Khan, 1990). Distributional patterns of the flora in salt affected habitats often reveal strong associations of specific taxa with certain types of soil solutes. Solute composition, along with salinity and habitat stability, may provide a template shaping the distribution of many plants inhabiting saline habitats. Studies on habitat associations, specific solute tolerance, and ionic and osmotic adaptations of a particular species provide evidence about the fidelity to particular conditions (Herbst, 2001). Since saline desert conditions are rare in nature, this kind of typical habitat is very unique. Plants inhabiting such conditions are very different and, therefore, phytoecological studies of saline habitats in desert conditions are useful for understanding of adaptive mechanisms.

The vegetation in hostile and typical desert conditions of Cholistan survives by possessing adaptations, which may be specific to each species. Many edaphic factors including soil moisture, salinity, pH, etc. determine the vegetation pattern in saline habitats. Therefore, a very specific flora is found to be associated with these saline habitats depending upon extent of salt tolerance and specific adaptation. Thus it is necessary to determine the association of such flora with extent of soil salinity of these habitats. The phytosociological associations of the Cholistan desert flora with its soil characteristics have not been reported. This study reports the soil-plant interaction, distribution, and species association of different distinct saline habitats types in the Cholistan desert varying in soil salinity.

Materials and Methods

Five vegetation study sites located on the inter-dunal saline flats in the Cholistan desert were selected for evaluation of phytosociology and species association (Fig. 1). The selection criterion was based on extent of soil salinity and some other soil physico-chemical characteristics. Derawar Fort (DF) was the least saline among the study sites and the average soil physico-chemical characteristics were pH: 8.39; ECe: 17.27 dS m^{-1}; Na^+, 3532.72 mg L^{-1}; Cl^-, 1529.09 mg L^{-1}. Trawaywala Toba (TT) was the moderately saline site and the average soil physico-chemical characteristics were: pH, 8.33; ECe, 24.80 dS m^{-1}; Na^+, 4200.90 mg L^{-1}; Cl^-, 2348.18 mg L^{-1}. Baliahwala Dahar (BD) was also the moderately saline site and the average soil physico-chemical characteristics were: pH, 8.35; ECe, 26.9 dS m^{-1}; Na^+, 4405.20 mg L^{-1}; Cl^-, 2481.32 mg L^{-1}. Ladam Sir (LS) was the highly saline site and the average soil physico-chemical characteristics were: pH, 8.28; ECe, 46.30 dS m^{-1}; Na^+, 5087.54 mg L^{-1}; Cl^-, 2503 mg L^{-1}. Pati Sir (PS) was the highest saline site and the average soil physico-chemical characteristics were: pH, 8.26; ECe, 46.30 dS m^{-1}; Na^+, 5359.45 mg L^{-1}; Cl^-, 2720.34 mg L^{-1}.

For vegetation sampling, 20 regular quadrats (each of 10 m^2) were laid at each habitat along a straight transect line, each separated by a distance of 20 m at each site. The data for frequency and density were recorded for each species and relative frequency and density values, importance value, Simpson's diversity index, and species association were calculated following the method of Ludwig & Reynolds (1988).

The data were subjected to statistical analysis following Steel *et al*., (1997) for the calculation of LSD and SE.

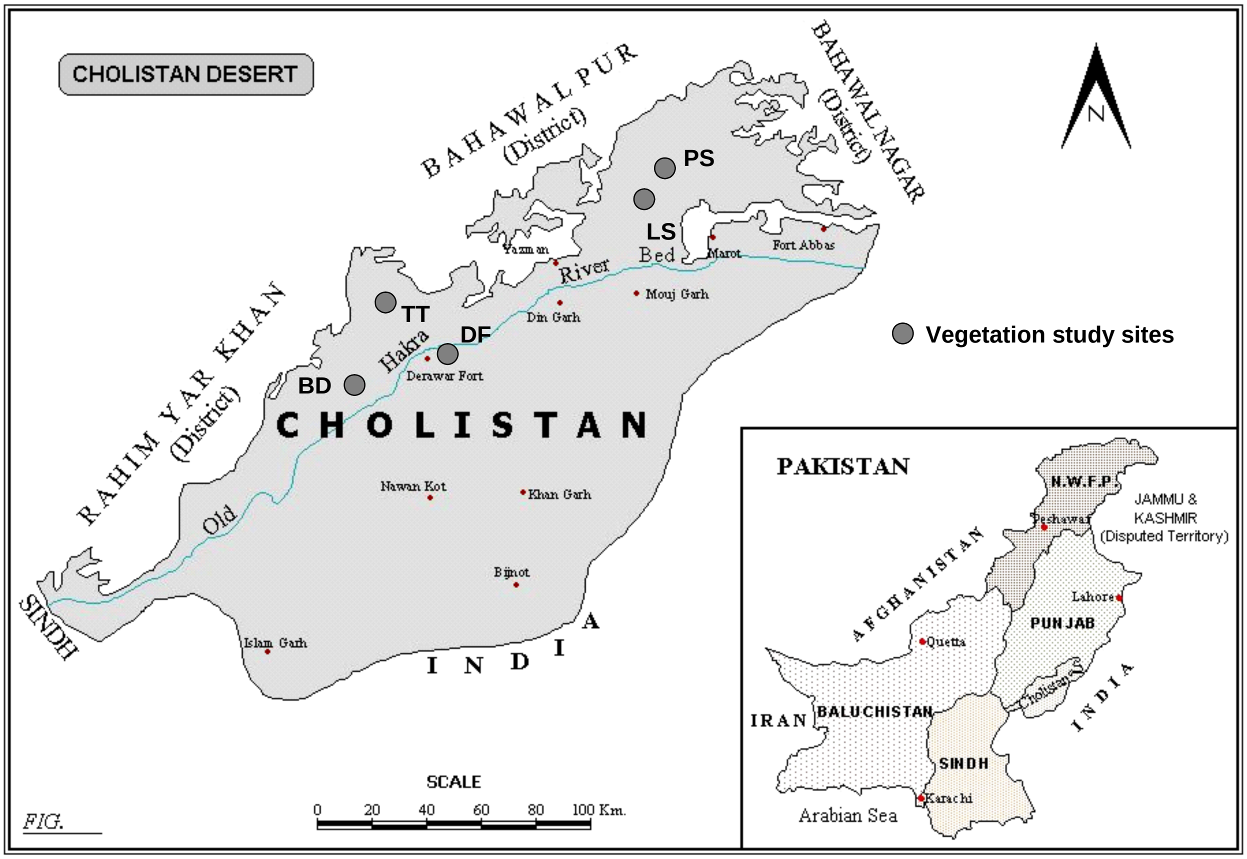

Fig. 1. Map of Cholistan desert showing vegetation study sites. Derawar Fort (DF, 29º 24' 32.67" N, 71º 27' 32.34" E), Trawaywala Toba (TT, 29º 10' 27.65" N, 71º 09' 21.57" E), Bailahwala Dahar (BD, 29º 38' 19.43" N, 70º 93' 23.37" E), Ladam Sir (LS, 30º 53' 26.53" N, 72º 64' 24.62" E) and Pati Sir (PS, 30º 35' 17.58" N, 72º 63' 22.45" E). Modified after Akhtar & Arshad, 2006).

Results

Phytosociological studies: *Sporobolus ioclados* was the most dominant grass species, because it was found in all the study sites. However, its distribution and dominance increased, particularly at the moderately saline sites, but decreased at high saline sites (Figs. 2&3). Two grasses, *Cymbopogon jwarancusa* and *Ochthochloa compressa* had higher frequency than that of the other grasses, particularly at moderate and highly saline sites. The distribution of *Aeluropus lagopoides* was not affected by increasing salinity levels of the habitats. The frequency and density of *L. scindicus* increased with increase in salinity level of the habitat.

Among dicots, *Haloxylon recurvum* was the most dominant species and it was closely followed by *H. salicornicum.* Moderate salinities resulted in an increase in the density and frequency of these two species, but higher salinities significantly reduced their number. Relative density and frequency of *Cressa cretica* and *Figonia indica,* increased at moderate salinities as compared to those from the least saline habitat, but the value of both these parameters considerably decreased at highly saline habitats (Figs. 2&3).

Species association: At the lowest saline site (DF), highly significant association of *A. lagopoides* was found with *C. jwarancusa*, *S. ioclados* and *Suaeda fruticosa* (Fig. 4). There was a significant association of *C. jwarancusa* with *S. ioclados* and *S. fruticosa,* while highly significant association of *L. scindicus* with *Fagonia indica,* and of *S.*

ioclados with *S. fruticosa* was also found at this site. At moderately saline (TT), *A. lagopoides* showed highly significant association with *C. jwarancusa, S. baryosma* and *S. fruticosa,* but significant with *S. ioclados* (Fig. 3). A significant association was recorded for *C. jwarancusa* with *S. baryosma* and *S. fruticosa,* and that for *L. scindicus* with *F. indica*. *Ochthochloa compressa* showed a significant association with *Cressa cretica* and *H. recurvum,* while *S. ioclados* with *S. baryosma* at this site.

At the second moderately saline site (BD), *A. lagopoides* showed highly significant association with *C. jwarancusa, H. recurvum* and *S. fruticosa,* while significant with *S. ioclados* and *S. baryosma* (Fig. 4). Highly significant association of *C. jwarancusa* was observed with *O. compressa, H. recurvum* and *S. fruticosa* and significant with *S. ioclados*. *Lasiurus scindicus* was significantly associated with *H. recurvum,* and *S. ioclados* with *S. fruticosa* at this site.

At highly saline site (LS), highly significant association of *A. lagopoides* with *C. jwarancusa* and *S. fruticosa,* and significant with *O. compressa, S. ioclados* and *H. recurvum* was observed at this site (Fig. 4). Similarly, highly significant association of *C. jwarancusa* was observed with *O. compressa* and *S. fruticosa,* and of *S. ioclados* with *S. fruticosa*. At the other highest saline site (PS), *A. lagopoides* showed highly significant association with *S. ioclados* and *S. fruticosa*, while *C. jwarancusa* with *S. fruticosa*. Similarly, highly significant association was shown by *L. scindicus* with *F. indica* and *H. recurvum,* and significant with *H. salicornicum*. However, a significant association was observed between *S. ioclados* and *S. fruticosa* at this site.

Discussion

Species association in relation to different grasses and dicots varies significantly as the salinity level of the habitat increased. These associations among the species are mainly dependent on their degree of salt tolerance and the salinity level of the habitat. In this study, *Cressa cretica* showed no association with other species recorded in the present study, except *Ochthochloa compressa* at moderately saline TT. In addition, the density of this species increased up to moderate salinities and thereafter decreased with an increase in soil salinity. This species has been reported as a dominant component of halophytic communities (Asri & Ghorbanli 1997, Milović & Marković, 2003), but it showed optimal growth on moderate salinities (Dagar 1998). This may be the reason that it had strong association with relative by less tolerant species like *Ochthochloa compressa* at moderate salinities.

Fagonia indica showed a strong association with *Lasiurus scindicus,* and both these species probably were more adapted to xeric environments, and therefore, considered as moderately tolerant to salinity. This has been strongly supported by the findigs of Iqbal *et al*., (2002) who reported *F. indica* as an inhabitant of less saline soils.

At moderately saline site (TT), *H. recurvum* was associated with *O. compressa,* but it indicated a shift towards *L. scindicus*, *C. jwarancusa* and *A. lagopoides* at the moderately saline site (BLD). However, at higher salinities (LS), *H. recurvum* was found to be associated only with *A. lagopoides* and *H. salicornicum*. *Aeluropus lagopoides* has been rated as a highly salt tolerant species by different researchers (Gulzar *et al*., 2003; Naz *et al*., 2009), therefore, the strong association of both *H. recurvum* and *H. salicornicum,* particularly at high salinities can be justifiable. Khan *et al*., (2000) rated both these species as highly salt tolerant.

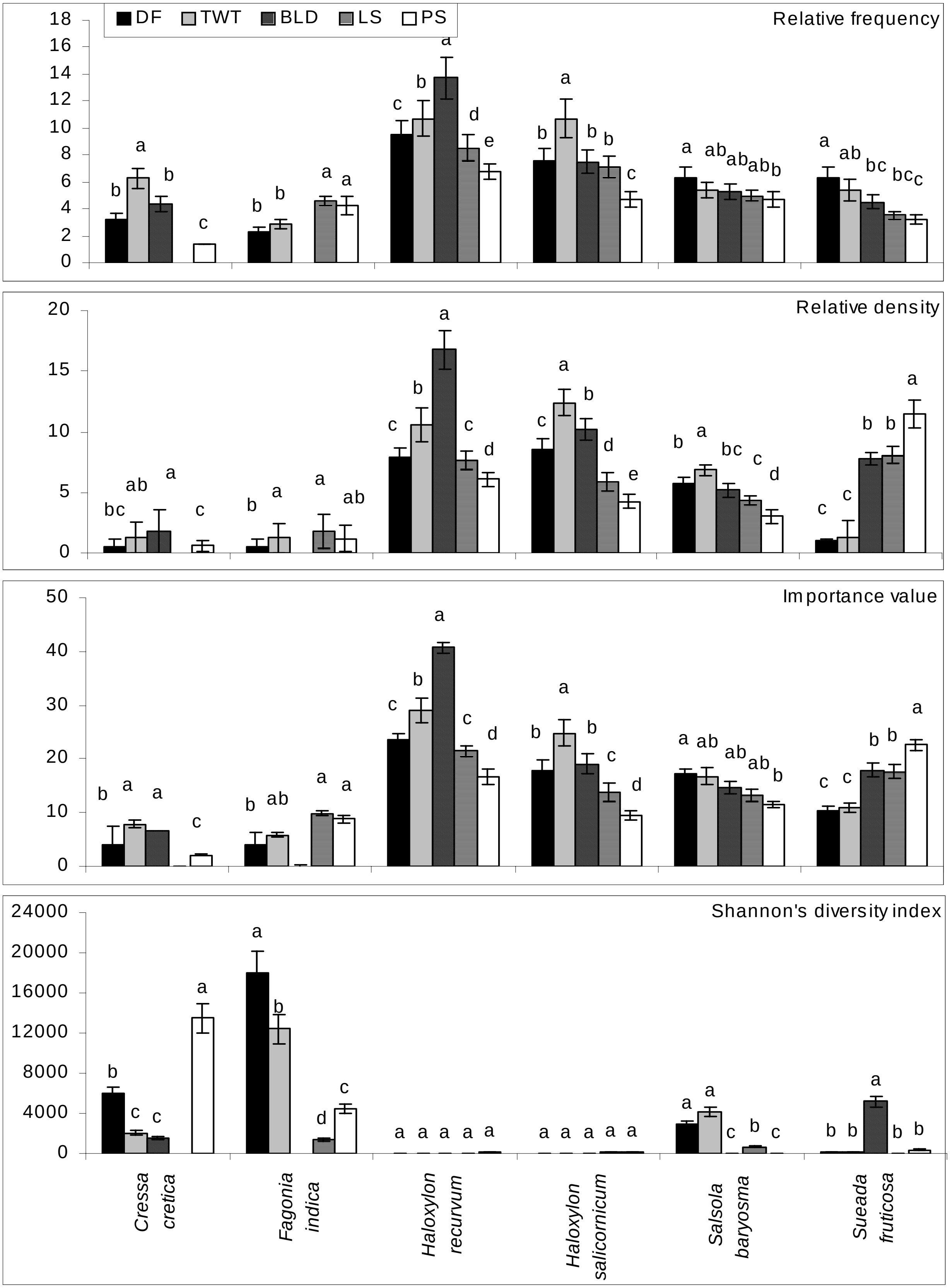

Fig. 2. Phytosociological studies (dicot species) of some salt affected sites of the Cholistan desert (DF = Derawar Fort, TT = Trawaywala Toba, BD = Bailahwala Dahar, LS = Ladam Sir, PS = Pati Sir).

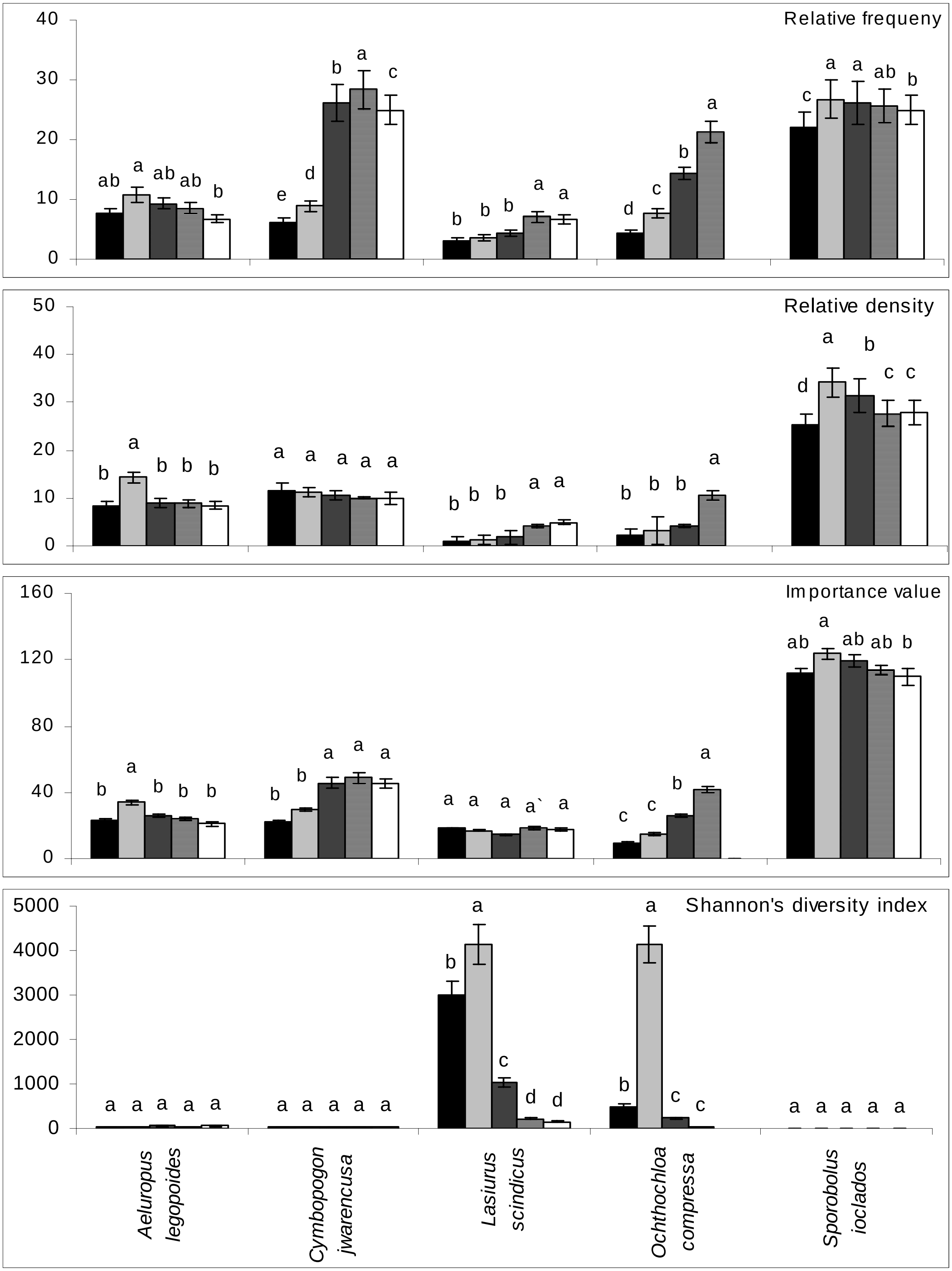

Fig. 3. Phytosociological studies (grass species) of some salt affected sites of the Cholistan desert (DF = Derawar Fort, TT = Trawaywala Toba, BD = Bailahwala Dahar, LS = Ladam Sir, PS = Pati Sir).

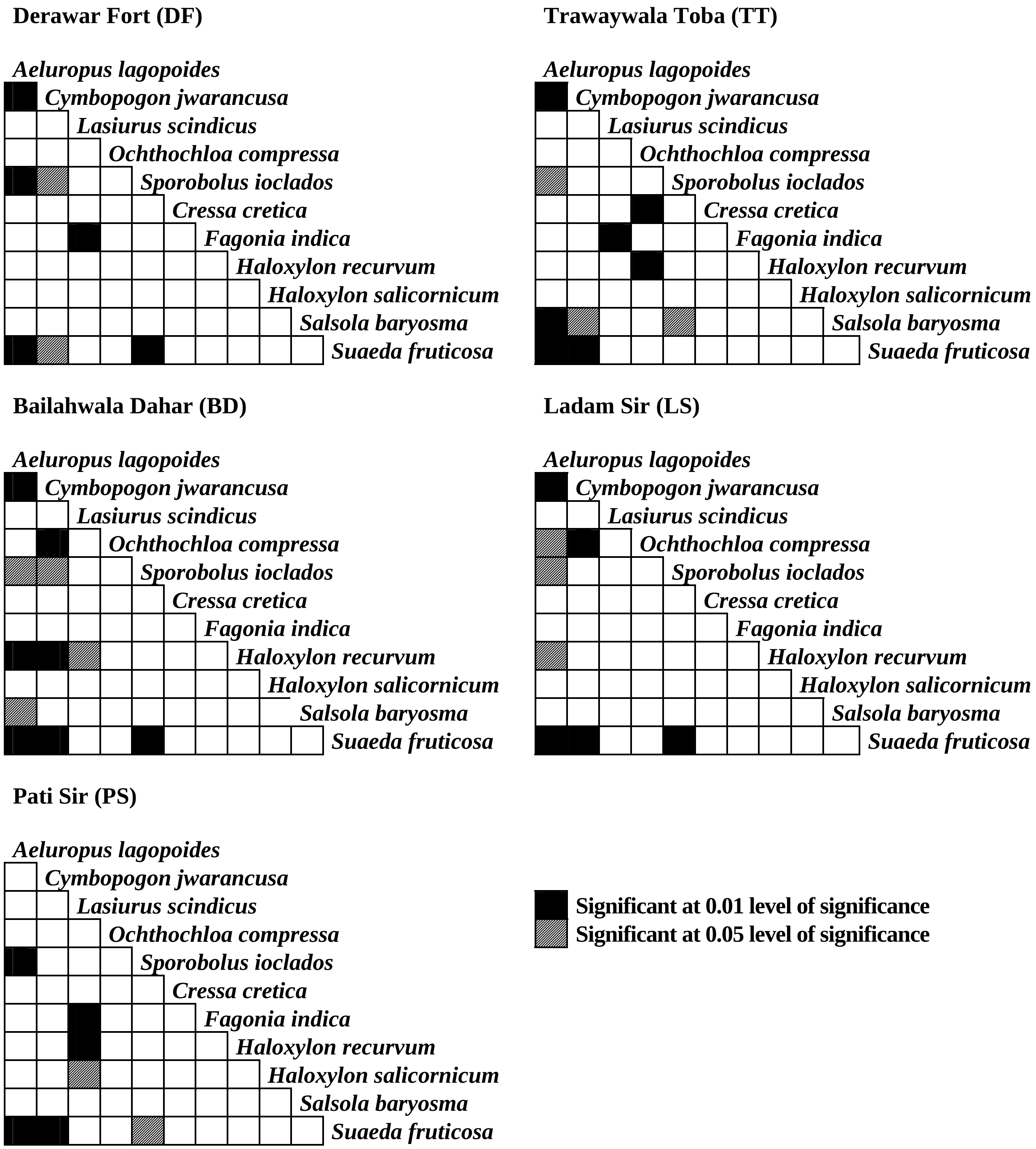

Fig. 4. Species association analysis of plant species at saline affected habitats in the Cholistan desert.

Salsola baryosma had strong associations with *Sporobolus ioclados*, *C. jwarancusa* and *A. lagopoides*, but only at moderate salinities (TT and BD). Dagar (1995) rated this species as highly salt tolerant, but in the present study (at higher salinities) some other factors may contribute to the distribution of this species (Arshad *et al*., 2008).

Suaeda fruticosa, on the other hand, had a strong association with other species such as *S. ioclados*, *C. jwarancusa* and *A. lagopoides* at all habitats, while with *H. recurvum* at only moderately saline habitat (BD). High salt tolerance of this species has been reported by Khan *et al*., (2000), and therefore, the association of this species with highly salt tolerant species can be easily expected.

Aeluropus lagopoides had a strong association with *C. jwarancusa* and *S. fruticosa* at each habitat. However, in less salt affected sites it was mainly associated with *S. ioclados*, while at moderately saline sites, it was associated with moderately tolerant species such as *S. ioclados*, *H. recurvum* and *S. baryosma*. These results can be explained in the light of an earlier study of Pignatti (1982) who reported the association of *A. lagopoides* with *C. cretica* in inland and coastal halophytic communities.

At the highest saline sites, *Cymbopogon jwarancusa* was associated with *H. recurvum* and *H. salicornicum.* However, at lesser saline habitat it showed a greater association with *C. cretica, H. recurvum,* and *A. lagopoides*. The distributional pattern of this species was little erratic, therefore, it is predicted that some other edaphic factors may have been responsible for its distribution, eg., annual temperature and precipitation (Skarpe, 1990). *Lasiurus scindicus* is a moderately salt tolerant grass (Singh *et al*., 2004). This species had a high association with *F. indica* at all habitats studied, which is also a less tolerant species as compared with the others species.

Sporobolus ioclados had a strong association with *A. lagopoides*, *C. jwarancusa* and *S. fruticosa* irrespective of habitat type, but at lesser salt affected habitat it was mainly associated with *S. baryosma*. Gulzar *et al*., (2005) rated this species as highly salt tolerant, and hence, its strong association with some other halophytic species can be expected as reported by Naz *et al*., (2010).

In conclusion, distributional pattern of individual species seemed to be mainly affected by the salinity level of the habitats, but the highly salt tolerant species were not much affected along the salinity gradient. In addition, the association of species appeared to be dependent on the degree of salinity tolerance of individual species. Relatively high salt tolerant species like *Aeluropus lagopoides, Sporobolus ioclados, Suaeda fruticosa,* and *Haloxylon recurvum,* showed a broad range of association at all study sites irrespective of salinity level of the habitat. In contrast, in moderately salt tolerant species, the association seemed to be entirely dependent on the salinity level of the habitat type.

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