BIODIVERSITY AND PHYTOSOCIOLOGICAL STUDIES OF UPSTREAM AND DOWNSTREAM RIPARIAN AREAS OF PAKISTAN: SPECIAL REFERENCE TO TAUNSA WILDLIFE SANCTUARY AND KETI SHAH FORESTS

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ABSTRACT:- Pakistan riparian zone mostly belongs to Sindh and Punjab provinces and prone to climatic problems and anthropogenic activities. The research was conduct to estimate and compare the structure and composition of riverine floral diversity in low riparian zone of River Indus. The data was collected from Keti Shah forest and Taunsa wildlife sanctuary. Total 14259 plants/individuals were recorded, which belong to 54 plant species with 18 different families. In Taunsa pre-monsoon survey, total 30 plant species were found with 4476 plants from 16 different families. In Taunsa post-monsoon survey total 3348 individuals were recorded from 20 plant species and 9 families. Similarly, in Keti Shah forest, total 3975 individual were recorded from 22 species and 11 families during the pre-monsoon season and 2460 plants were recorded in post-monsoon season, belonging to 16 species and 10 families. These species mostly belong to Fabaceae, Poaceae, Cyperaceae and Asclepiadaceae. Different phytosociological *parameters indicate Tamarix dioca, Cynodon dacty*lon, *Desmostachya bipinnata, Imperata cylindrica, Fimbristylis hispidula, Acacia nilotica, Phragmites karka, Tamarix* sp. and *Saccharum bengalense* as dominant species. The biodiversity in upstream and downstream areas were rich in pre-monsoon season in comparison to post-monsoon season in surveyed areas. This study is useful for management of the area in the future as conservation strategies can be made through considering the adaptive tree species in future plantation and endangered species can be conserved.

Key Words: Keti Shah Forest; Taunsa Wildlife Sanctuary; Biodiversity; Phytosociology; Life Forms; Riparian Forest; River Indus; Pakistan.

INTRODUCTION

There is increasing interest in the importance of rivers ecologically, geomorphologically, hydrologically and environmentally. The scientific literature on riverine ecosystem is rapidly expanding (Van der Velde et al., 2004). The available literature highlights the fluvial and structuring process of riverine ecosystem especially in relation to abiotic factors. The linkage between the river paths and wetlands creates "boom" and "bust" ecology (Jenkins and Boulton, 2003).

Diversity of Pakistan is distinctive as the country shelters three bio-geographic realms i.e., the Indo-Malayan; Palaearctic and Africo-

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tropical (UNEP, 1995). About two-third of the country is mountainous and rapid changes in altitude aggravate differences in diversity within short distances. Pakistan includes variety of terrestrial ecosystems within 18 major geographical zones i.e., permanent snowfield and cold desert, alpine meadow, subalpine scrub and birch forest, dry temperate coniferous forest, Himalayan moist temperate forest, sub-tropical pine forest, tropical deciduous forest, steppic forest in the Northern latitude, intermediate and the Southern latitude, monsoon-influenced arid sub-tropical, less pronounced monsoon influenced, Balochistan desert scrub, Indus plains, sand dunes, inundation (seepage and swamp) zones, riverine tract and littoral (inter-tidal) zone. In addition, a number of different agro-ecosystems have been created through the conversion of natural habitats for agricultural use (Roberts, 1997).

Riparian zones possess an unusualy diverse array of species and environmental processes. The eco-logical diversity is related to variable flood regimes; geographically unique channel processes, altitudinal climate shifts and upland influences on the fluvial corridor. The resulting dynamic environment supports life-history strategies, biogeochemical cycles and organisms adapted to disturbance regimes over broad spatial and temporal scales. Riparian zones play essential roles in managing riparian vegetation, water and landscaping planning, in restoration of aquatic systems and in catalyzing institutional and societal cooperation for these efforts (Gregory et al., 1991; Naiman and Décamps, 1997; Rood et al., 2007).

Taunsa Barrage situated at 31° 31' N and 70° 51' E in the south-western part of Punjab in Tehsil Kot Addu district Muzaffargarh was built over river Indus in 1958. Taunsa Barrage wildlife sanctuary comprises alluvial plains of fine to grained soil dominated with deposits of calcar-eous nature. A wildlife sanctuary at Taunsa Barrage was declared during 1978 under Punjab Wildlife Act 1974. Its total area is 2834 ha (WWF, 2014). Its wildlife sanctuary is worldwide famous for habitat of Indus blind dolphin (*Platanista minor*). The climate of the area is arid with extremely hot summers (39-46 °C during June) and mild winters (5-19 °C). The average annual rainfall is about 200 mm of which 80% is received in summers. Relative humidity in the area varies from 25% to 88%. The wind velocity remains around 15-30 km h^{-1}; however, during summers it exceeds up to 30-35 km h^{-1} with dust storms and haze. The wind directions are from north to south or from north-west towards south-east. It often turns to storm during summer months (Khurshid and Chaudhry, 1998).

Keti Shah forest is situated in the vicinity of Sukkur city, Sindh, Pakistan. Sukkur district covers 5165 km^2, 27° 43´21.63´´ N and 68° 50´ 40.94´´ E on map. It shares northern border with Shikarpur and Kashmore districts, southern border with Khairpur districts, north-eastern border with Ghotki and eastern border with India. Climatically, It has hot climate and with temperature range of 6°-46°C during the year. Keti Shah forest (7346 ha) is a part of the riverine forest ecosystem in Sukkur. The species composition in low lying frequently inundated areas comprises *Acacia nilotica* and mixture of *Acacia nilotica* and other species including *Prosopis cineraria*, *Tamarix* spp. and

Populus euphratica (WWF, 2013).

Siddiqui et al. (2010) have examined quantitative vegetation of temperate coniferous forest of Himalayan region of Pakistan. They separated vegetation into different groups. Group I was dominated by *Pinus wallichiana* stand; group II was dominated by *Abies pindrow* and group III was dominated by *Cedrus deodara*. In Keenjhar Lake District Sindh seven plant communities were dominated which includes *Tamarix sarenensis, Populus euphratica* and *Luffa echinata* (Akbar et al., 2010). Shah and Hussain (2009) analyzed 5 plant communities, each having its own species composition in Hayat Abad, District Peshawar. They described *Poaceae, Brassicaceae, Solanaceae* and *Asteraceae* as richest families. In life forms, therophytes dominates cryptophytes and in leaf size spectra *Microphyllous dominates* were studied more (40%) than lepto-phylls (22%). Edaphic and phyto-sociological parameters of south Waziristan vegetation during autumn season. They report great variation in biomass production due to difference in air and soil temperature were noticed. Moreover, the original vegetation was altered due to over grazing and deforestation. In another study in Pirghar hills South Waziristan agency reported by life form and leaf form on the basis of altitude difference. They reported that original woody species present on the hills are mainly isolated due to degradation.

Since there was no previous study that reports the phytosociological perspectives of Taunsa wildlife sanctuary and Keti Shah forest of Pakistan, the present study was conducted to delineate both the plant communities of low riparian zones.

MATERIALS AND METHOD

Sampling Technique

The study area (Taunsa wildlife sanctuary and Keti Shah forest) was surveyed once during pre and post-monsoon seasons using the line intercept method (Canfield, 1941; Kent and Coker, 1992; Mueller-Dombois and Ellenberg, 2013). Due to dense vegetation transect line of 50 m was used to sample the study area (Canfield, 1941) and by placing 1 m^2 quadrat at alternate sides after 10 m interval on the same transect. For woody plant-ation, 10 m × 10 m quadrat was used on same transect line after 20 m interval. Transects were ran-domly distributed all over the area using Geographical Information System maps of the area.

Plant Collection and Identification

During the field survey each floral species was collected and identified with the help of available literature on Identification and Standard Nomen-clature from Department of Botany, Karachi University, Pakistan. A complete floristic list along with families was compiled according to the Standard Nomenclature (Ali and Qaiser, 1997-2010; Nasir and Ali, 1971-1996; Stewart, 1972).

Phenology

The phenological observations were recorded during the vegetation sampling and plants were classified into (a) seedling stage (young and pre-flowering), (b) flowering, (c) fruiting and (d) dormant (fruiting or life cycle completed). These observations were made according to Fenner (1998) and Ahrends et al. (2008).

Life Form (Biological Spectrum)

The life form classes and their

percentage in each community was based upon Raunkiaer (1934). Hussain and Malook (1984) and Mueller-Dombois and Ellenberg (2013). The major classes were: (a) Phanerophytes (P): Tree and shrub species in which the buds are borne 0.25cm-2.00 m above ground surface; (b) Chamaephytes (Ch): Their perennating buds are situated 25 cm above ground surface; (c) Hemicryphotophytes (H): Herbaceous perennials whose aerial portion die at the end of growing season leaving perennating bud at or just beneath ground surface; (d) Cryptophytes (C): Plant buds are situated below ground surface as bulb; tuber; rhizome etc. and (e) Therophytes (Th), seed producing plants who complete their life cycle in one year.

Phytosociological Studies

The following phytosociological attributes were measured from each site during field data collection.

Frequency

It is the percentage of sampling plots in which a given species occurs and shows the distribution and occurrence of the species. It was determined according to Hendry and Grime (1993). Using following formula:

$$\text{Frequency} = \frac{\text{Number of quadrats in which species occure}}{\text{Total number of quadrats}} \times 100 \quad (1)$$

Later, the relative frequency was calculated using formula:

$$\text{Relative frequency} = \frac{\text{Frequency of a species}}{\text{Total frequency of all species}} \times 100 \quad (2)$$

Density

Density of plant species were obtained by dividing total number of individuals of the species in all the quadrats by the total number of quadrats examined (Hendry and Grime, 1993).

$$\text{Density} = \frac{\text{Number of individuals of a species}}{\text{Total number of quadrats}} \quad (3)$$

After calculating the density; the relative density was calculated using formula:

$$\text{Relative density} = \frac{\text{Species density}}{\text{Density of all species}} \times 100 \quad (4)$$

Cover

Cover is the perpendicular projection of crown or shoot of a species to the ground surface measured as a fraction or percentage of a surface area (Hendry and Grime, 1993). The cover was calculated using formula:

$$\text{Cover} = \frac{\text{Species total length of intercept}}{\text{Total transect length}} \times 100 \quad (5)$$

The relative cover was calculated using formula:

$$\text{Relative cover} = \frac{\text{Total length of a species intercept}}{\text{All species intercept length}} \times 100 \quad (6)$$

Importance Value

The measure of relative dominance of species in a particular forest community is the importance value (IV) and was estimated by following the method of Curtis and McIntosh (1950) and Stephenson and Adams (1986).

IV = Relative frequency + Relative
density + Relative cover   (7)

Summed Dominance Ratio

Summed Dominance Ratio (SDR) was estimated using data from importance values according to Kobayashi et al. (2003) .

$$SDR = \frac{Importance\ value}{3} \quad (8)$$

RESULTS AND DISCUSSION

The study evaluates the dynamics of riverine flora of low riparian zone in Taunsa wildlife sanctuary and Keti Shah forest during pre and post-monsoon seasons. Total 240 transect lines of 50 m were laid in evaluated forest areas and data regarding plant species and phytosociological studies were recorded.

Floristic Composition

Total 14259 plants were recorded, belonging to 54 plant species with 18 different families. In Taunsa pre-monsoon survey, 30 plant species with 4476 plants from 16 different families were recorded. They belongs to Poaceae, Fabaceae and Asteraceae. While, in Taunsa post-monsoon survey, 3348 plants of 9 different families and 20 species were found belonging to Poaceae, Cyperaceae and Asclepiad-aceae.

In Keti Shah forest, 6435 plants were surveyed, and 22 plant species were recorded that belong to 11 different families. During pre-monsoon season, 3975 plants were recorded that mainly belongs to Fabaceae, Asteraceae and Poaceae while in post-monsoon season 2460 plants were surveyed that belongs to 16 plant species with 10 different families. evaluated the riparian forest in Sindh province of Pakistan. The important riparian species in the evaluated province was *Acacia arabica, Dalbergia sissoo; Tamarix* spp*., Salix* sp*., Morus alba, Populus euphratica* and other *Populus* species.

Phenology

The vegetation within the riparian zone performs an important ecological function for in-stream processes. Large scale disturbances; such as high water flows and flooding, are likely to be important factors in the dynamics of the riparian community (Barnes, 1985; Bradley and Smith, 1986; Johnson, 1994*).* The phenological observations were recorded during the vegetation sampling and plants were classified into; (a) seedling (young and pre-flowering) (b) flowering (c) fruiting and (d) dormant (fruiting or life cycle completed).

During pre-monsoon in Taunsa wildlife sanctuary, out of 30 plant species total 19, 7, 2 and 2 plants were on flowering, seedling, fruiting and dormant stages, respectively while during post-monsoon season 9, 7, 3 and 1 species were on stage above mentions, respectively (Figure 1). In Keti Shah forest during pre-monsoon season, 13, 5 and 4 species were on flowering, seedling and dormant stages, respectively. While in post-monsoon season, 7, 4, 4 and 1 species were on fruiting, flowering, dormant and seedling stage, respectively (Figure 1).

Different plant species within a community may share phenological patterns. These may share some of their morphological and physiological adaptations and also some have similar patterns in phenology because of close phylogeny (Wright and Calderon, 1995) Marques et al. (2004).

pointed out that phenologies in Araucaria forest in Southern Brazil is associated with the climatic variables, day length and temperature and to some extent with rainfall.

Life Forms

Biological spectrum of vegetation is the index of the phytoclimate of the site, deduction of which is based on different life-forms composing the flora of the site. The life-form in its turn is the ultimate manifestation of the sum of all the adaptations undergone by a plant to the climate in which it resides. Raunkiaer (1934) proposed the term "Biological Spectrum" to express both the life-form distribution in a flora and the phytoclimate under which the prevailing life-forms evolved. The life forms of Taunsa wildlife sanctuary in pre-monsoon season, revealed 9 therophytes; 7 phanerophytes; 7 chamaephytes; 4 cryptophytes and 3 hemicryptophytes (Figure 2). Whereas, in post-monsoon season 5 phanerophytes, 5 cryptophytes, 5 hemicryptophytes, 4 therophytes and 1 specie belongs to chamaephyte was recorded.

In comparison which to Keti Shah forest during pre-monsoon season species comprised 6 chamaephytes, 5 phanerophytes, 5 cryptophytes, 4 therophytes and 2 hemicryptophytes. Similarly, in post-monsoon season, 6 phanerophytes, 4 chamaephytes, 3 cryptophytes, 2 hemicryptophytes and 1 therophyte species were recorded (Figure 2).

Bouri and Mukherjee (2011) studied the biological spectrum in tropical deciduous Sal forest in Bankati Gram Panchayat area under Durgapur Forest Range, Burdwan District, West Bengal based on 71 plant species of angiosperms revealed that out of hundred species of its flora, 63.38 are phanerophytes, 1.41 chamaephytes, 8.45 cryptophytes, 7.04 hemicryptophytes and 19.72 therophytes. The phytoclimate appears to be of phanerotherophytic type. The recent studies recommends vegetation spectrum when working at smaller scales, due to under representation of therophytic population and overrepresentation of phanerophytes (Batalha and Martins, 2002). Also the vegetation biological spectrum
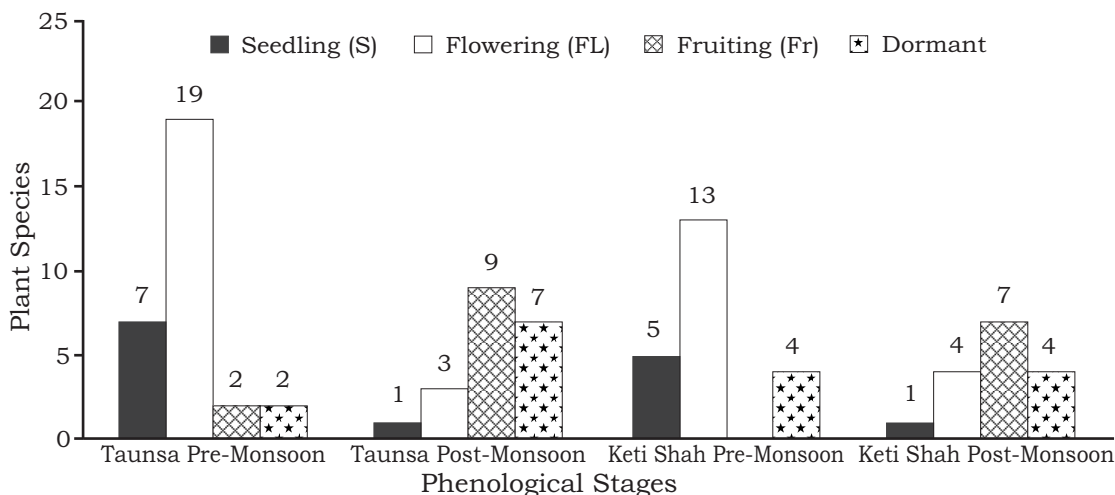

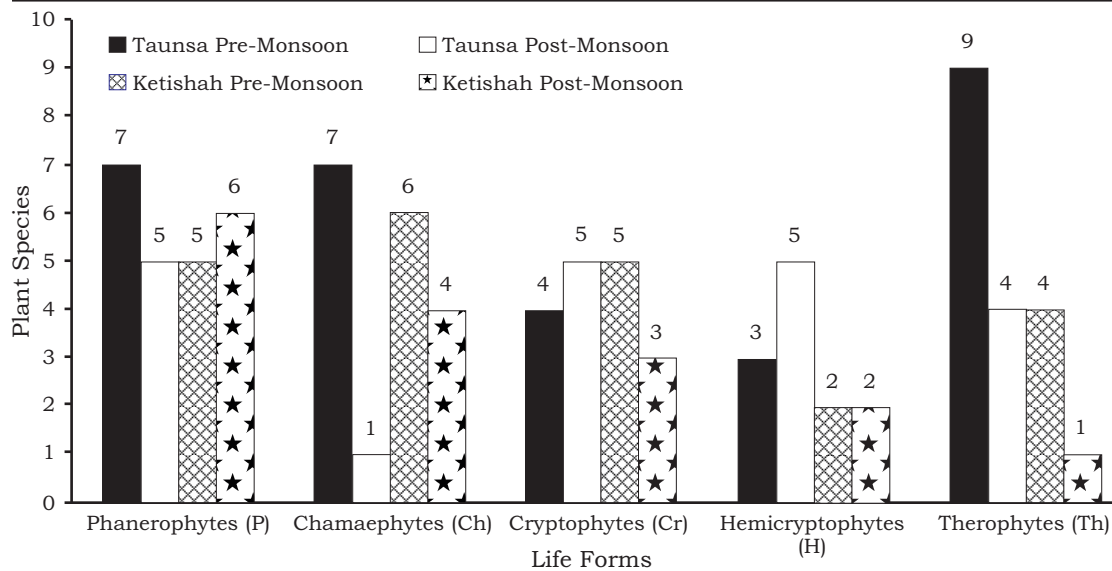**Figure 1. Plant phenology from different seasons in Taunsa Wildlife Sanctuary and Keti Shah Forest**

Figure 2. Plant life forms of Taunsa Wildlife Sanctuary and Keti Shah Forest in pre and post-monsoon seasons

is more readily comparable to biological spectra similarly constructed for other sites. The biological spectra of different regions of India have been worked out by Meher-Homji (1964) Pandey and Parmar (1993) Pattanaik et al. (2007): Rana et al. (2002) Reddy et al. (2002) Sharma and Dhakre (1993). Thus the biological spectrum of different regions may be worked out and used to compare the widely separated plant communities in terms of their climatic adaptbility.

Phytosociological Studies

These are essential for protecting the natural plant communities and biodiversity as well as understanding the changes experienced in the past and continuing on into the future. Phytosociological parameters, like frequency, density and cover, calculated for each study site were as follows:

Taunsa Wildlife Sanctuary
Frequency

Average maximum frequency in the pre-monsoon season was 59.17% for the *Cynodon dactylon*. Similarly, *Saccharum spontananeum* followed by *Cynodon dactylon* with 51.67% and 20.04 relative frequency. *Tamarix dioca* was found with the 40.84% and 16.7 relative frequency. In *Acacia nilotica* frequency was 15.84% and 6.21 relative frequency. Average minimum frequency of 0.83% was calculated for the *Conyza camadasis, Dalbergia sissoo, Eclipta prostrata, Lythyrus aphaca, Mentha* sp*, Oxystlma esculentum, Ranunculus muricatus* and *Zizyphus mauritiana.* Similarly, the least values of the relative frequencies were observed for the same plant species as for minimum frequency (Figure 3).

Average maximum frequency of the each species during post-monsoon season was calculated as 45.84% for *Saccharum spontaneum* with the relative frequency value of 20.31 followed by *Tamarix dioca* and *Cynodon dactylon* with 37.50% and 30.34% frequency, respectively. Average mini-

mum frequencies were recorded for *Arundo donax, Cyperus rotundus, Echinocloa crusgalli, Launea procumbense* and *Saccharum bengalense* were of 0.83%, 1.67%, 1.67%, 1.67% and 2.5% respectively (Figure 3).

Density

The average and relative densities during pre-monsoon for the *Cynodon dactylon, Saccharum spontananeum,* and *Imperata cylindrica* were 2.42 m^2 and 23.58, 1.69 m^2 and 22.61, and 1.23 m^2 and 11.94, respectively. Average minimum density of 0.01 m^2 was recorded for *Zizyphus mauritiana* with the relative density of 0.08. Other species found with lowest density and relative density values were *Arundo donax, Conyza camadasis, Dalbergia sisso, Eclipta prostrate, Lythyrus aphaca, Mentha* sp., *Oxystlma esculentum* and *Ranunculus muricatus* (Figure 4).

Density and relative density was found higher in *Saccharum spontaneum* (1.5 m^2 and 23.82, respectively) as compared to the *Cynodon dactylon* and *Tamarixdioca* with 1 m^2 and 0.77 m^2 density. *Desmostahya bipinnata* was also present in the stand with density of 0.66 m^2 and 8.73 relative frequencies. Average minimum density was 0.02 m^2, 0.05 m^2, 0.04 m^2, 0.04 m^2 and 0.06 m^2 for *Arundo donax, Cyperus rotundus, Echinocloa crusgalli, Launea procumbense* and *Saccharum bengalense* with lowest values of the relative density. *Populous euphratica* had density of 0.04 m^2 and 0.70 relative density.

Cover

The average maximum cover of 23.67% was found for *Saccharum spontaneum* with the relative cover of 26.71 (Figure 5). *Cynodon dactylon, Tamarix dioca, Imperata cylindrica*
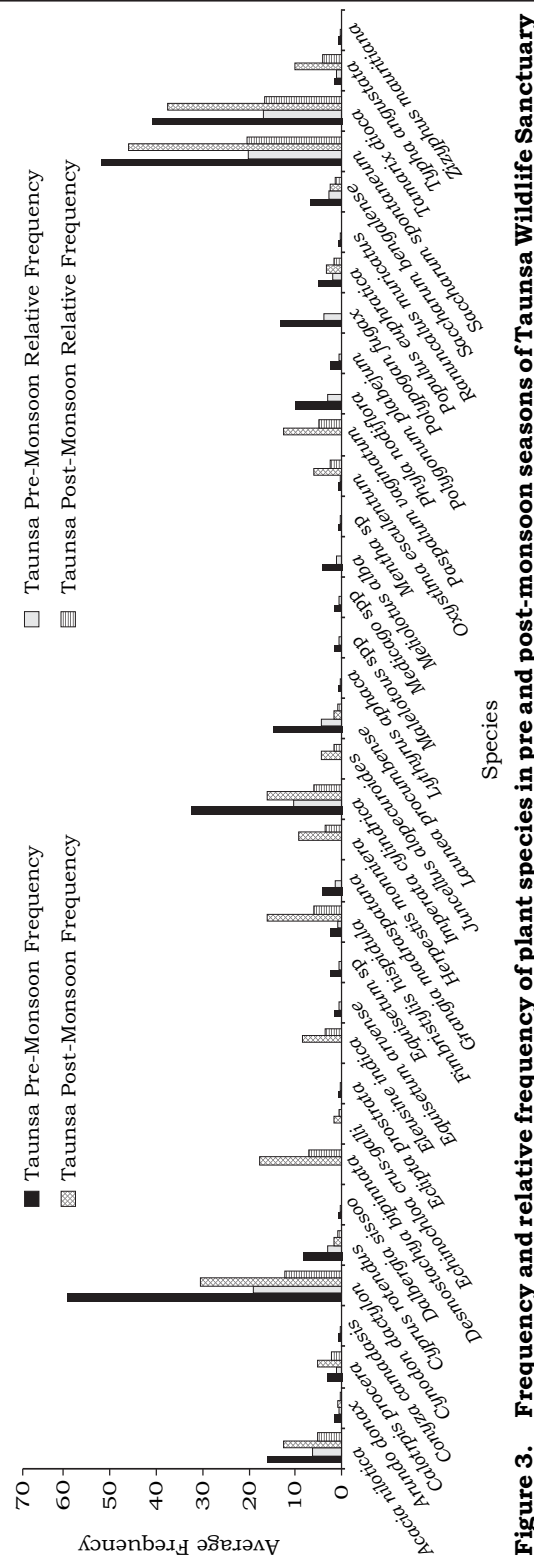

Figure 3. Frequency and relative frequency of plant species in pre and post-monsoon seasons of Taunsa Wildlife Sanctuary
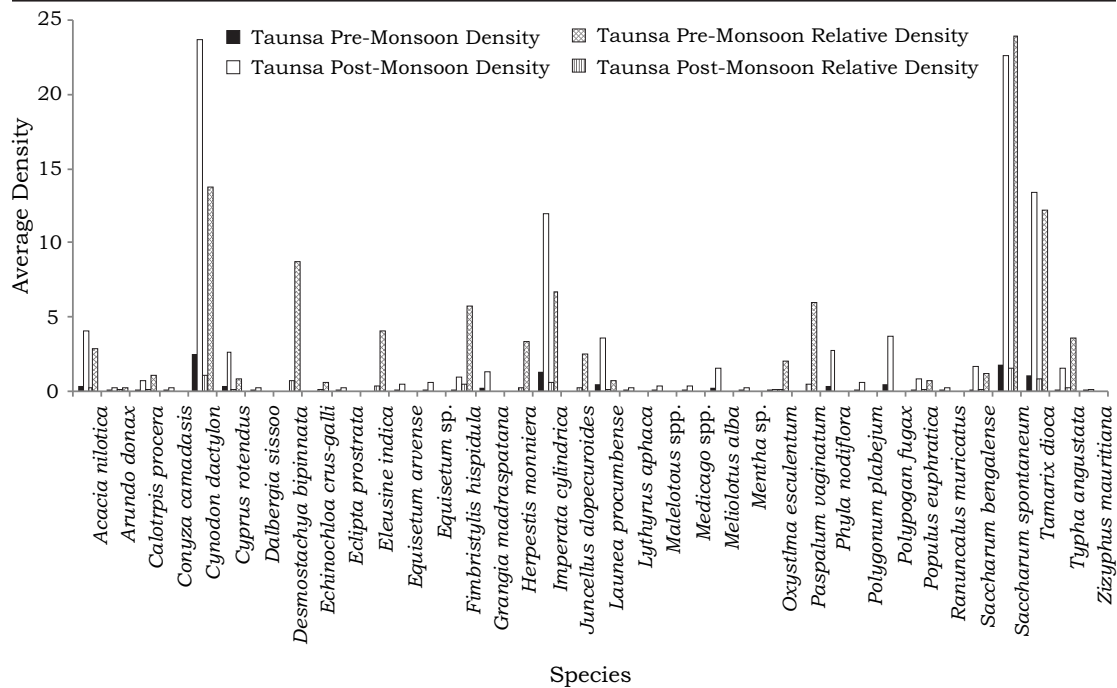
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Figure 4. Density and relative density of plant species in pre and post-monsoon seasons of Taunsa Wildlife Sanctuary

and *Acacia nilotica* was found with the cover of 19.40%, 15.83%, 8.68% and 6.51%, respectively. Average minimum cover was 0.02%, 0.01%, 0.03%, 0.02%, 0.01% and 0.01% for the *Conyza camadasis, Eclipta prostrate, Lythyrus aphaca, Mentha* sp., *Oxystlma esculentum* and *Ranunculus muricatus*, respectively (Figure 5).

Maximum cover value was calculated for *Saccharum spontaneum* 2.33% and relative cover of 26.67. Similarly *Tamarix dioca* and *Cynodon dactylon* covers the 14.02% and 8.72%, respectively. *Desmostachya bipinnata* and *Acacia nilotica* covers the 6.92% and 4.81 % of the area with 8.53 and 6.06 relative cover, respectively . Average minimum cover percent of 0.18, 0.21, 0.07, 0.23 and 0.26 was found for *Arundo donax, Cyperus rotundus, Echinocloa crusgalli, Launea procumbense* and *Saccharum bengalense*.

Importance Value and Summed Dominance Ratio (SDR)

Maximum average importance value was found for *Saccharum spontaneum* (69.35), *Cynodon dactylon* (66.30), *Tamarix dioca* (47.88), *Imperata cylindrica* (32.26) and *Acacia nilotica* (17.59) (Figure 6). Average minimum importance value was recorded for the *Conyza camadasis, Eclipta prostrate, Lythyrus aphaca, Mentha* sp*., Oxystlma esculentum* and *Ranunculus muricatus*, respectively. Average maximum SDR was calculated for the *Saccharum spontaneum* (23.12), *Cynodon dactylon* (22.10), *Tamarix dioca* (15.96), *Imperata cylindrica* (10.75) and *Acacia nilotica* (5.86). Average minimum SDR was recorded for the *Conyza camadasis, Eclipta prostrate, Lythyrus aphaca, Mentha* sp., *Oxystma esculentum* and *Ranunculus muricatus*, respectively.
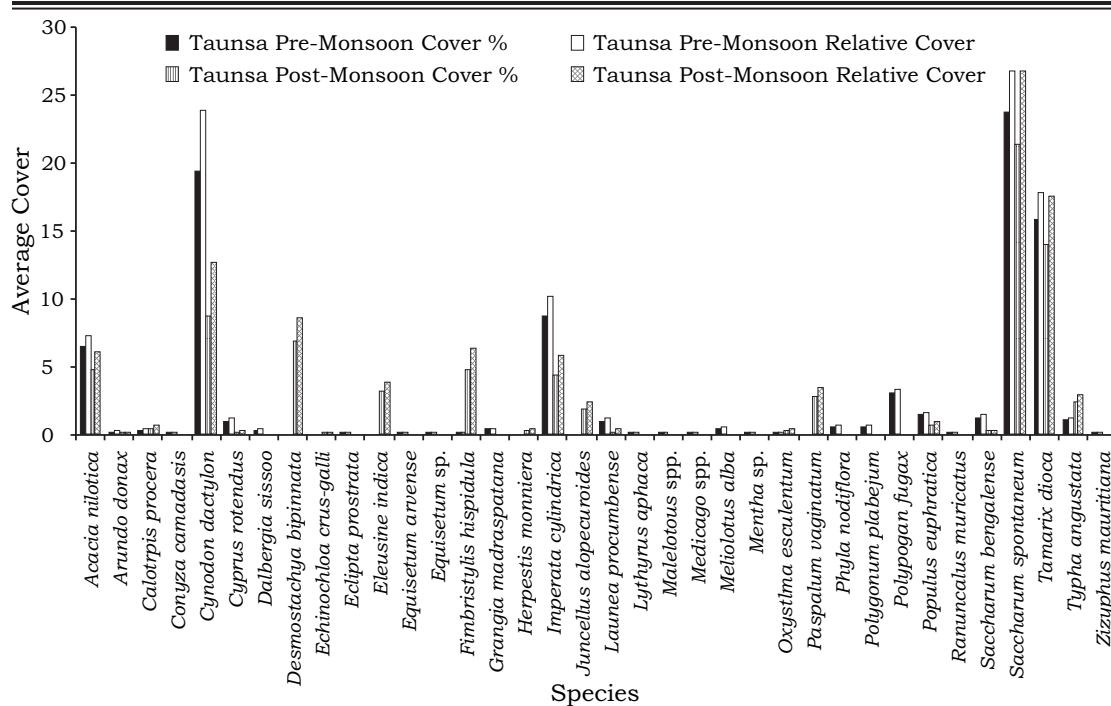
Figure 5. Cover and relative cover of plant species in pre and post-monsoon seasons of Taunsa Wildlife Sanctuary

Importance value and SDR was found higher for *Saccharum spontaneum* with 70.8 and 23.6, respectively, as compared to the *Tamarix dioca* and *Cynodon dactylon* 46.14 and 38.36, respectively (Figure 6).
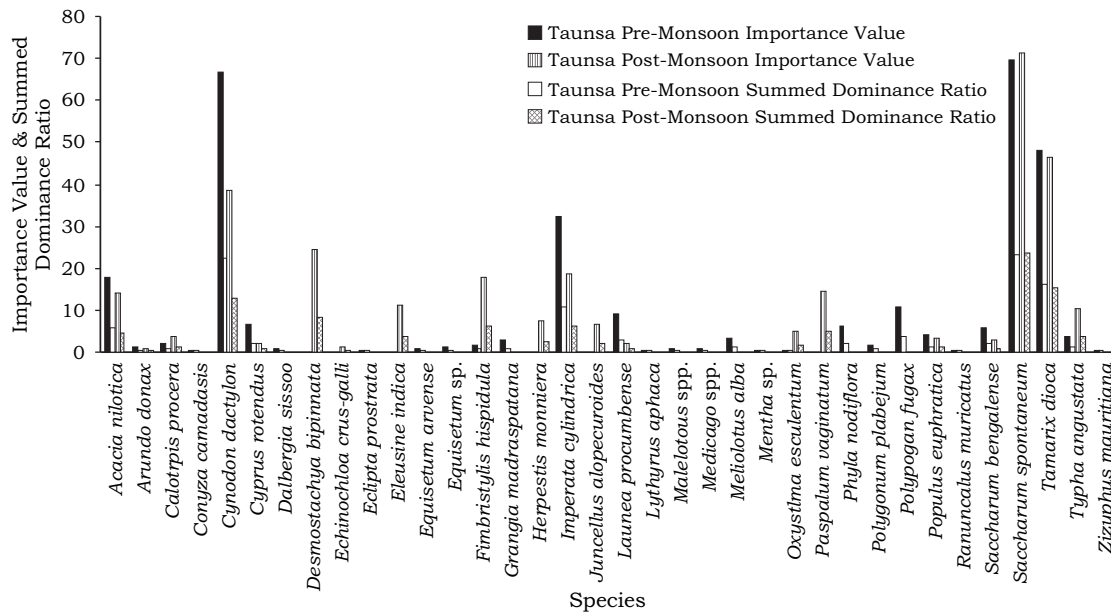

Figure 6. Importance value and summed dominance ratio of plant species in pre and post-monsoon of Taunsa Wildlife Sanctuary

Desmostachya bipinnata was also present in the stand with 24.21 importance value and 8.07 SDR. Other species with higher importance value and SDR were *Imperata cylindrica*, *Fimbristylis hispidula* and *Acacia nilotica*. Species with the minimum average importance values and SDR were *Arundo donax, Cyperus rotundus, Echinocloa crusgalli, Launea procumbense, Saccharum bengalense* and *Populous euphratica*.

Mansoor et al. (2002) evaluated the diversity of plant species in Lal Suhanra National Park, Bhawalpur, Pakistan and observed similar trend in plant species. They mentioned *Acacia nilotica* and *Dalbergia sissoo* as dominant plant species in the park. Moreover, the ranking (importance) in evaluated area shows *Saccharum spontananeum, Cynodon dactylon* and *Tamarix dioca* as dominant species. Campos and Souza (2002) conducted the phytosociological analysis in alluvial forest of the upper Paraná River floodplain. They sampled 795 individuals distributed among 28 families, 41 genera, and 47 species. The total density was 1.472 ha^{-1}, with a volume of 175.79 m^3. The specie importance during post-monsoon indicates *Saccharum spontananeum* and *Tamarix dioca* as main species in Taunsa wildlife sanctuary. The results agree with Mansoor et al. (2002).who pointed *Tamarix aphylla* as dominant plant species after monsoon period in Lal Suhanra National Park, Bhawalpur, Pakistan. Ahmed et al. (2006) performed quantitative phytosociological survey in 184 sampling stands in various climatic zones of Himalayan forests of Pakistan. Their floristic composition and importance values showed 24 different communities and 4 monospecific forest vegetations. Their results showed similar floristic composition in various climatic zones however they differ in quantitative values.

Keti Shah Forest

Frequency

Average maximum frequencies of 45.84%, 37.50%, 33.33%, 31.25%, 25% and 25% were found for *Phragmites karka, Phyla nodiflora, Tamarix indica, Cynodon dactylon, Launaea procumbense, Saccharum bengalense* and *Acacia nilotica*, respectively (Figure 7). While, average minimum frequencies were recorded for the *Cyperus* sp., *Eclipta prostrata, Melilotus indica, Oxysytelma esculentum* and *Prosopis cineraria*. In post-monsoon season average maximum frequency of 41.67% was recorded for *Tamarix indica* and relative frequency calcu-lated was 18.83 followed by the *Acacia nilotica* with frequency value of 33.34% and 15.52 relative frequency. The average minimum frequency values was recorded 2.08% for *Eclipta prostrata, Fimbristylis bisumbellata, Mukia madraspatana, Phyla nodiflora, Populus euphratica* and *Prosopis cineraria* with minimum relative frequency of 0.74 for *Eclipta prostrate* and *Mukia madraspatana* (Figure 7).

Density

The maximum density values in pre-monsoon season was recorded for *Phragmites karka* (2.13 m^2), *Phyla nodiflora* (0.94 m^2), *Tamarix indica* (0.75 m^2), *Cynodon dactylon* (1.36 m^2), *Launaea procumbense* (0.75 m^2), *Saccharum bengalense* (0.90 m^2) and *Acacia nilotica* (0.42 m^2), respectively (Figure 8). Average minimum density of 0.06 m^2, 0.04 m^2, 0.02 m^2, 0.02 m^2 and 0.04 m^2 was recorded for the *Cyperus* sp., *Eclipta prostrata, Melilotus indica, Oxysytelma escu-*
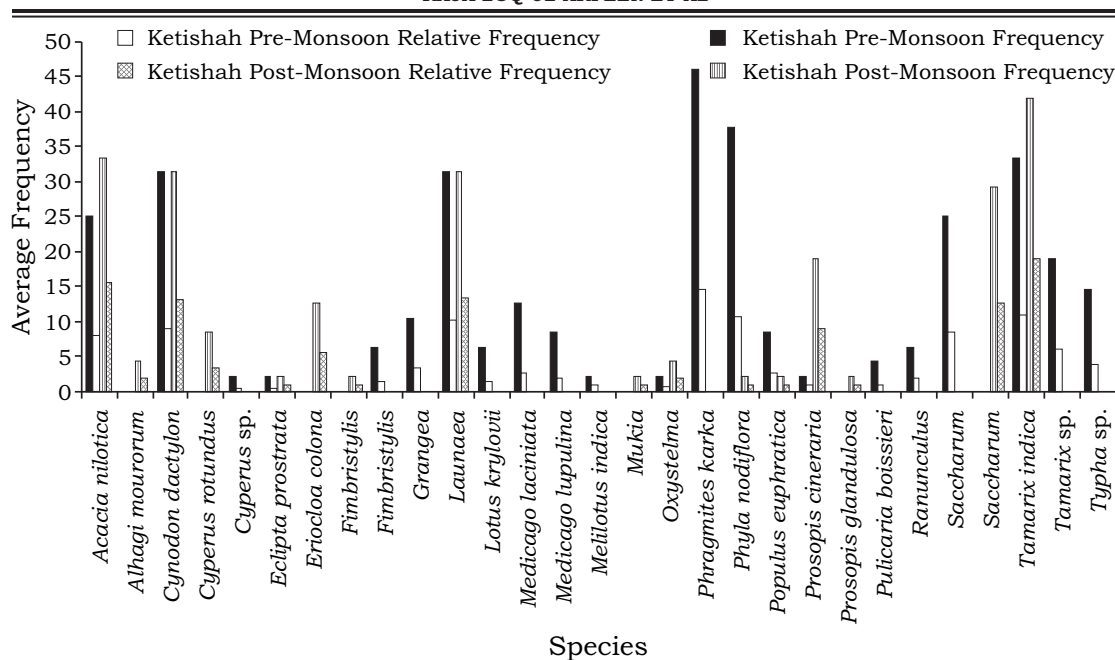
Figure 7. Frequency and relative frequency of plant species in pre and post-monsoon seasons of Keti Shah Forest

lentum and *Prosopis cineraria,* respectively, with the relative density of 0.51, 0.34, 0.26, 0.28 and 0.51, respectively. In post-monsoon season of the Keti Shah forest (Figure 8), average maximum density 1.48 m² was calculated for the *Saccharum spontaneum* and 1.02 m² for *Cynodon dactylon* with the maximum relative density of 23.18 for *Saccharum spontaneum*. Average minimum density of 0.02 m² was computed for *Eclipta prostrata, Mukia madraspatana, Populus euphratica* and *Prosopis glandulosa* with minimum relative density of 0.26 for *Eclipta prostrata* and *Mukia madraspatana.*

Cover

The percent cover of plant species (Figure 10) during pre-monsoon season was maximum 13.92, 14.04, 11.65, 10.9, 9.77, 6.14 and 6.11 for *Phragmites karka,* Tamarix indica, Tamarix sp., *Cynodon dactylon,*

Saccharum bengalense, Typha sp. and *Acacia nilotica,* respectively (Figure 9). Average minimum cover percent was found for *Cyperus* sp., *Eclipta prostrata, Melilotus indica,* and *Oxysytelma esculentum. O. esculentum* and *Cyperus* sp. have cover of only 0.01% and 0.02% and also have least values of relative cover. In comparison to post-monsoon season average maximum coverage of 23.40% and 19.28% was found for *Tamarix indica* and *Saccharum spontaneum,* respectively. *Acacia nilotica* was found with 17.56% cover. Maximum 27.64 relative cover was calculated for *Tamarix indica* (Figure 9).

Importance Value and Summed Dominance Ratio

Importance value and SDR calculated showed that maximum values belong to the *Phragmites karka* 56.55 and 18.85, *Tamarix indica*
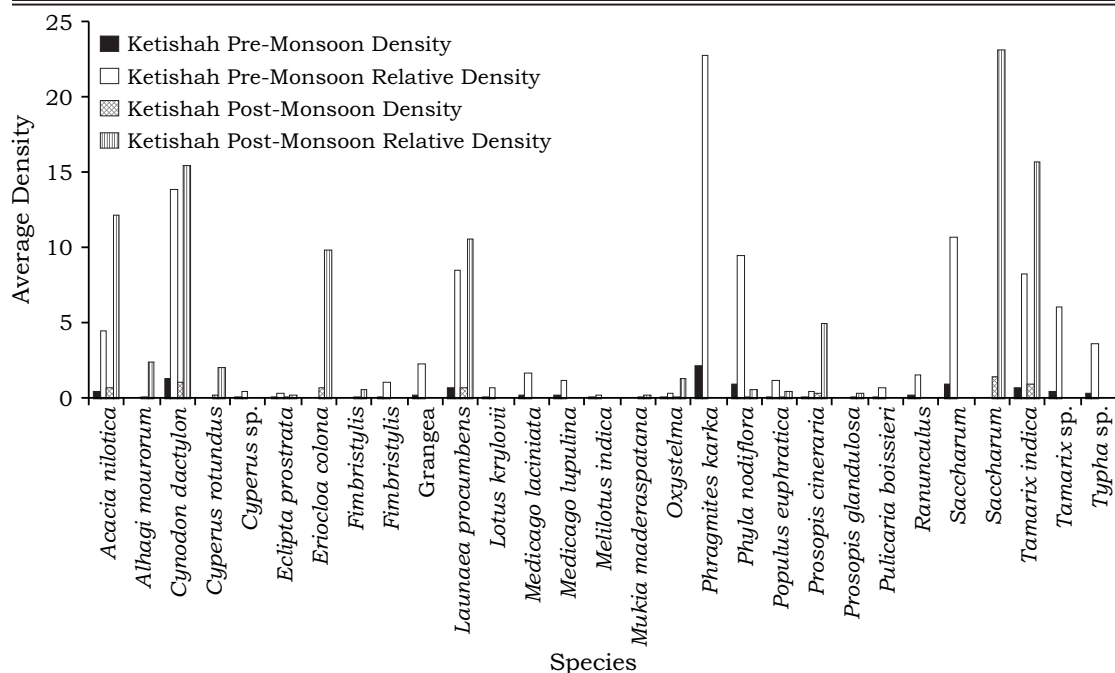
Figure 8. Density and relative density of plant species in pre and post-monsoon seasons of Keti Shah Forest

35.82 and 11.94, *Tamarix* sp. 26.57 and 8.86, *Cynodon dactylon* 36.7 and 12.23, *Saccharum bengalense* 29.82 and 9.94, *Typha* sp. 15.27and 5.09, and *Acacia nilotica* 18.7 and 6.23 (Figure 10). Average minimum importance value and SDR was found for *Cyperus* sp., *Eclipta prostrata*,
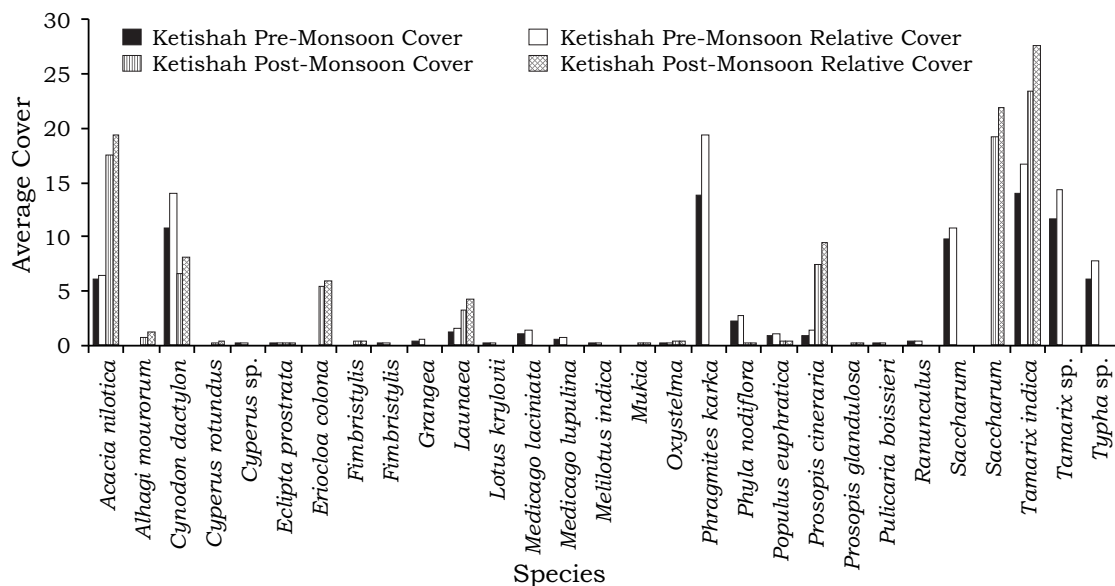

Figure 9. Cover and relative cover of plant species in pre and post-monsoon seasons of Keti Shah Forest

Melilotus indica, and *Oxysytelma esculentum. Oxysytelma esculentum* and *Eclipta prostrata* presents only 1 and 0.33, and 0.89 and 0.3 importance value and SDR, respectively.

The results regarding pre-monsoon season of Keti Shah indicate dominant frequent grasses as *Phragmites Karka, Tamarix indica, Cynodon dactylon* and *Saccharum bengalense.* The frequent herbs in area include *Phyla nodiflora* and *Launaea procumbense* and *Acacia nilotica* as a common tree species. Comparatively higher density was observed in *Phragmites karka.* Similarly, maximum cover percentage was seen in *Tamarix indica* and *Phragmites karka.* These species have higher importance value in terms of density, cover and frequency. The relative abundance of *Phragmites karka* in observed area are well in line with the study of Qureshi (2008). He reported the dominant frequency of *Phragmites karka* in Sawan Wari, Pakistan.

Average maximum importance value of 62.13 belongs to *Tamarix indica* followed by the *Saccharum spontaneum* with 57.67 importance value (Figure 10). Similarly, SDR of 20.71 and 19.22 was recorded for *Tamarix indica* and *Saccharum spontaneum,* respectively. Average minimum importance value of 1.06 was found for *Mukia madraspatana* and 1.08 for *penultimate Eclipta prostrata.* Similarly, average minimum SDR was calculated for *Mukia madraspatana.*

The results regarding post-monsoon season of Keti Shah indicate dominant frequent grasses as *Cynodon dactylon* and *Saccharum spontaneum.* The frequent herb in area include only *Launaea procumbense* and frequent tree species include *Acacia nilotica* and *Prosopis cineraria.* Comparatively, higher frequency was observed with shrubs. Similarly, maximum cover percentage was seen in *Tamarix indica* and is well comparable with pre-monsoon season. The maximum importance value found
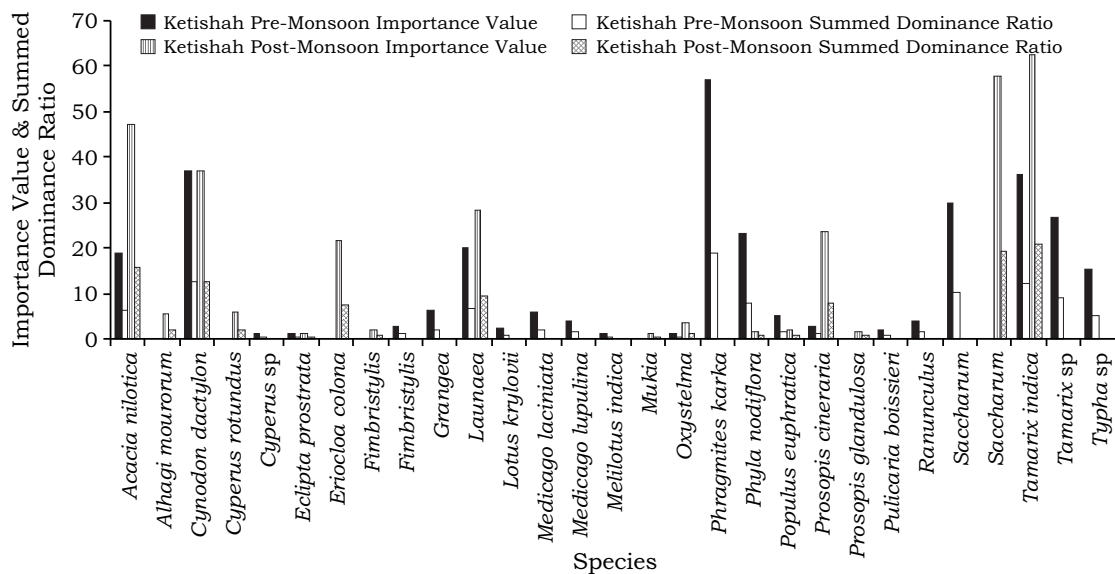

Figure 10. Importance value and summed dominance ratio of plant species in pre and post-monsoon seasons of Keti Shah Forest

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in Keti Shah for *Tamarix indica*, *Saccharum spontaneum* and *Acacia nilotica*.

Shah et al. (1985) pointed relative abundance of these species in riparian areas of Pakistan. Chaudhry et al. (2001) conducted phytoecological studies in the Chhumbi Surla wildlife sanctuary, Chakwal, Pakistan. They reported 116 plant species belonged to 35 families with Poaceae as the largest family with 41 grass species. The major grass species were *Dactyloctenium scindicum, Cymbopogon jwarancusa,* and *Dichanthium foveolatum*. They reported major shrubs and trees as *Acacia modesta*, *Dodonaea viscosa* and *Justicia adhatoda*. While major herbs included *Lespedeza floribunda, Pupalia lappacea* and *Diclyptera bupleuroides*. Similarly, Durrani et al. (2004) recorded 202 species of 45 plant families from Harboi rangeland Kalat. *Asteraceae, Papilionaceae, Poaceae, Brassicaceae* and *Lamiaceae* were the important families. They reported dominant life forms as therophyte and hemicryptophyte while nanophylls, microphylls and leptophylls were dominant leaf sizes. Qureshi and Bhatti (2005) reported 160 plant species belonging to 118 genera and 45 families during floristic survey of Nara Desert Pakistan.

The study concluded that the floral diversity was more in upstream (Taunsa Wildlife Sanctuary) in comparison to downstream (Keti Shah Forest, Sukkur). In total 14,259 plant individuals were recorded which belong to 54 plant species and 18 different families. In Taunsa pre-monsoon survey, total 30 plant species was found with 4476 plants from 16 different families, in Taunsa post monsoon survey total 3348 recorded from 20 plant species and 9 families. Similarly, in Keti Shah forest, total 3975 individuals were recorded from 22 species and 11 families during the pre-monsoon season and 2460 plants recorded in post monsoon season belongs to 16 species and 10 families. The biodiversity in upstream and downstream areas were rich in pre-monsoon season as compared to post-monsoon season.

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AUTHORSHIP AND CONTRIBUTION DECLARATION

S. No	Author Name	Contribution to the paper
1.	Mr. Raja Zoq-ul-Arfeen	Conceived the idea, Wrote abstract, Methodology, Overall management of the article, Data collection, Data entry in SPSS and analysis, Result and discussion, Introduction, References
2.	Dr. Aamir Saleem	Technical input at every step
3.	Dr. Sarwat Naz Mirza	Technical input at every step
4.	Dr. Muhammad Akmal	Technical input at every step
5.	Mr. Hafiz Muhammad Tayyab	Data collection and entry
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