Pak. J. Bot., 42(2): 1173-1185, 2010.

MULTIVARIATE CLASSIFICATION AND DATA ANALYSIS OF VEGETATION ALONG MOTORWAY (M-2), PAKISTAN

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Abstract

A survey of motorway (M-2) roadside vegetation and soils was undertaken. In this study, phytosociological survey using Braun-Blanquet's approach was undertaken. The floristic data were analyzed by the TWINSPAN and DECORANA, computer programs in order to classify and provide baseline information about the study area. Two major and 16 sub-communities were recognized along 358 km long motorway. Floristic data was collected from 397 quadrats and 227 vascular plants species belonging to 75 families were recorded. TWINSPAN divided the vegetation of whole study area into 2 major communities, which are further divided into 16 sub-communities. The study also provides basic information for the implementation of conservation oriented planning and management to preserve and improve the road verges of M-2.

Introduction

The human impact has always been a dominant factor in affecting different aspects of earth environment. Among the various means of transportation, roads enjoy a prime position because these constitute the largest and most extensive functioning system of transport on the earth (Bayliss & Owens, 1990). In Pakistan presently about 80% of the goods and passenger traffic is on the roads and remaining 20% is carried by other modes, namely, railways and airways. Pakistan has a road network of about 228,206 km in length. Out of total, 7144 km consists of national and major highways. The length of secondary and regional roads is 117,356 kms. The first motorway of this proposed network, M- 2 was completed in 1997 between the Federal Capital Islamabad and Punjab provincial capital Lahore, which covers a distance of 358 km. This project involves three major river bridges, 8 interchanges, 27 flyovers, 17 bridges on canals, 39 bridges on drains, 4 overhead railway crossings, 183 subways and cattle creeps, 22 culverts on canals and 73 culverts on drains (Anon., 2001).

The roadside verges are as old as the roads themselves. In the past, they used to be in the form of unmanaged strips of ground where plants often matched the plants of adjacent fields. But modern multi-lane roads especially motorways have wide verges. The large area occupied by these verges and their potential for nature conservation means that they are too important to be neglected in conservation planning. Way (1977) in U.K reviewed that roadside verges can contribute greatly to conservation. In other countries, the environmental and conservation values of the verges have already been recognized (Ullmann & Heindl, 1989). In the Netherlands and Australia, many verges have been declared SSSI (Sites of Special Scientific Interest) and Roadside Nature Reserves (RNR).

In Pakistan, the recent increase in road network has inevitably resulted in an increase in the area of road verges. These road verges are home to a wide range of flora and fauna. Wide verges along motorways and national highways usually offer more diverse habitats and therefore are able to support a greater variety and number of species than the narrow strips along roads. However in Pakistan the National Highway Authority has planted exotic species of trees alongside the motorway and the other major roads that have reduced the conservation value of the habitats (Ahmad *et al.,* 2004).

Roadside vegetation possesses a high ecological value as being a habitat in its own right and as a potential biological corridor (Formann, 1995). Similarly roadside plants along with other urban vegetation exercise a positive influence on the climate by reducing the temperature and producing cool air (von Stulpnagel *et al*., 1990). There have been no surveys of the roadside vegetation at a regional level in Pakistan. However, some surveys have been carried out to record the floristic composition of the roadside flora at a local basis (Adnan & Rashid, 2001 & Akbar *et al.*, 2003). There still exists a great need for further surveys and studies of roadside vegetation in Pakistan.

The present study demonstrates the floristic survey of road verges alongside motorway and mainly focuses on identification of vegetation species and highlighting the importance of roadside verges as ecological habitats. The information solicited from these studies would help in furthering our knowledge of the ecological implications of man-made ecosystems, the dynamics of environmental processes and nature conservation. In addition, this information will serve as baseline information for comparison in future and socio-economic aspects of M-2.

Materials and Methods

The following criteria were observed during the selection of sites for the survey of roadside vegetation.

1. Plots were located systematically at 7 km intervals.
2. Sites with an established cover of vegetation along the verges were sampled only.
3. The disturbed roadsides (vehicle accidental area, fire effected area, oil leaked area etc**)** were avoided. If neither side of road was suitable, then the nearest suitable site within I km distance was selected. If no suitable site was available within 1 km, the sample point was omitted.
4. The total number of sampled stands is 50 and comprises of 397 quadrats.

In terms of climate, the entire region through which the M-2 passes falls within the category of sub-tropical, continental lowland type of climate, which is characterized by high summer temperatures and late summer monsoon rains (Chang, 1972), which generally concentrated in the June-September season. July and August are normally the rainiest months while October and November are the driest. Climatic data (mean monthly temperature and mean monthly precipitation) were obtained from the meteorological department (Table 1).

Zonation of road verges: During the pilot stage of survey, it was observed that in general, vegetation on the road verges could be divided into certain zones based on the variation of conditions and homogeneity of vegetation. Dowdeswell (1987) divided a typical road verge into outer zone, inner zone, ditch and bank or lope.
A site normally comprised of two zones:

Table 1. Climatic data of selected stations in the Sub-Humid, Semi-Mountainous Northern Region and Semi-Arid, Central Punjab Region.

	Chakri		Balkassar		Bhuchal Kalan		Bhera		Pindi Bhattian		Lahore	
	M.T.	**Rain**	**M.T.**	**Rain**	**M.T.**	**Rain**	**M.T.**	**Rain**	**M.T.**	**Rain**	**M.T.**	**Rain**
January	11.7	56.1	12.1	48.7	10	63.2	12.3	17.25	12.0	10	12.3	26
February	12.1	73.5	12.3	66.4	11.7	78	14.8	23.0	14.6	14.3	14.6	24.3
March	17.9	89.8	17.7	88.3	16.4	83.3	20.3	26.0	19.8	14.0	20.0	19.8
April	23.1	61.8	23	58.6	22.6	74.6	26.6	22.8	25.8	11.8	26.0	14.3
May	28.3	39.2	28.4	36	26.9	49.9	32.2	19.0	31.2	10.8	31.1	14.8
June	32.7	62.2	33.2	65.2	31.2	71.7	34.7	35.3	34.4	30.5	33.6	41.0
July	32	267	32.5	249.8	30.4	281.5	33.5	97.5	33.4	71.5	32.2	136.3
August	31.4	310	31.8	283.5	29.5	297.3	32.5	87.8	31.8	89.5	31.0	128.8
September	28.5	98	28.6	93.9	27	103.3	30.8	34.5	30.4	37.3	29.6	55.0
October	23.9	29.3	23.3	31.1	22.4	43.7	25.8	3.8	25.5	3.0	24.9	6.0
November	18.4	17.8	18	15.4	17.3	21.3	19.1	2.0	18.7	2.8	18.4	2.5
December	11.7	37.3	11.1	34.9	10.8	28.5	13.7	10.8	13.6	6.3	13.6	11.8
Annual	**22.64**	**1142**	**22.66**	**1071.8**	**21.35**	**1196.3**	**24.67**	**379.5**	**24.24**	**301.5**	**23.9**	**480.3**

Mean temperatures (M.T.) are in degree Celsius while the rainfall (Rain) is in mm. (Source Pakistan Meteorological Department).

Zone 1. Border zone: The road shoulder adjacent to the edge of road sealing. It was usually 1-3 m wide; soil is comparatively affected by traffic.

Zone 2. Verge zone: The fence zone which was demarcated from the adjacent private or state owned land by fence.

Plant data collection: For the collection of vegetation data Braun-Blanquet's approach (Braun-Blanquet, 1932) was used, which is yet recognized worldwide. In this approach, sampling is done by the use of relves / quadrats, which are vegetation samples that are not randomly located and carefully selected as representative area of a vegetation type (Kent & Coker, 1992).

Size of quadrats: A suitable size of quadrat is important for vegetation sampling. It is selected according to the size and spacing of plants. Based on the usual observations of vegetation structure, which comprised mostly of herbs and grasses, the quadrat size of 1 x 2 m was selected. A 100-meter long tape was laid down parallel to road randomly in each zone of the verge at each site (Fig. 1). One quadrat of 1 x 2 m was selected at the start of long laid tape as border zone and second at last point of border zone. Two quadrats were laid along tape in verge zone. The same method was applied on both sides of road.

During the survey more emphasis was laid on recording of vascular plant data, as other species do not contribute quantitatively to the vegetation on road verges. A total of 397 quadrats in 50 plots were taken for herbs and grasses. Within each quadrat, vascular plants and their estimated cover was recorded by visual estimation using the Domin cover scale (Kent & Coker, 1992). In addition a set of ecological descriptors for each site such as width, adjoining land use was also recorded. Land use adjoining the road reserve was designated as either dwelling in a village, cultivated cropland or an uncultivated area/ pastureland. Sampling was completed in 2002, and 2003. The seasons, which exhibit complete flourishing of vegetation, i.e., when most plants are in flowering was chosen. Nomenclature of vascular plants follows Nasir & Ali (1972).

Using classification and ordination techniques, multivariate analysis of the data was carried out. Classification is a widely used method for analyzing floristic data in plant ecology. It involves the sorting and arrangement of samples (quadrats) or species in a hierarchical fashion, into groups or classes, which possess certain common characteristics or attributes. To classify vegetation types, a cluster analysis was conducted by TWINSPAN (Hill, 1979).

Results

On the basis of the survey of the roadside borders and verges in the study area, which comprised of floristic data collected from 397 quadrats, 227 vascular plants species belonging to 75 families were recorded. These include 129 herbs, 38 shrubs or sub shrubs and 60 trees. Out of 227 species only 15 species occurred with a frequency of more than 9%. The roadside vegetation in the study area is dominated by *Cynodon dactylon, Calotropis procera, Cenchrus ciliaris, Heteropogon contortus, Bothrichloa pertusa* and *Rhynchosia minima*. Out of these *Cynodon dactylon, Calotropis procera, Cenchrus ciliaris and Heteropogon contortus* alone cover 35.90 % of the area sampled. These species therefore are identified as dominant and leading species of road verges in the study area in both qualitative and quantitative terms.

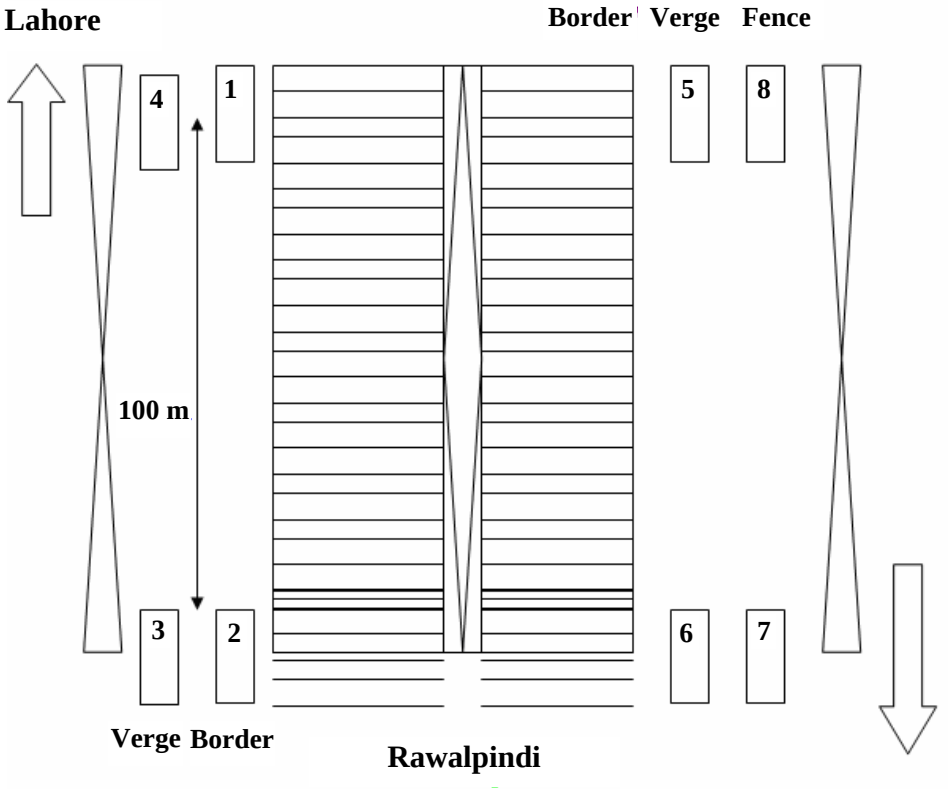

Fig. 1. Diagrammatic presentation of quadrats arrangement in the study area.

To classify the vegetation types, a cluster analysis (Classification algorithm) was conducted by TWINSPAN (Hill, 1979). Based on the analysis twelve major vegetation types were found. These results are presented in a dendogram (Figs. 2 & 3). These results clearly indicate that at the first level TWINSPAN divided the vegetation of whole study area into two major communities, which are further divided into sub-communities.

- **Major community 1:** *Cynodon dactylon, Calotropis procera and Cenchrus ciliaris*
- **Major community 2:** *Heteropogon contortus, Rhynchosia minima and Calotropis procera*

Sub-communities are:

1.1. *Tamarix aphylla, Saccharum munja* and *Convolvulus arvensis*
1.2. *Calotropis procera, Cynodon dactylon* and *Cenchrus ciliaris*
1.2.1. *Cynodon dactylon, Calotropis procera* and *Chenopodium ambrosioides*
1.2.1.1. *Heteropogon contortus, Calotropis procera* and *Oxalis corniculata*
1.2.1.2. *Cynodon dactylon, Tribulus terrestris* and *Cleome viscosa*
1.2.2. *Cynodon dactylon, Calotropis procera* and *Cenchrus ciliaris*
1.2.2.2. *Cynodon dactylon, Cleome viscosa* and *Calotropis procera*
1.2.2.2a. *Achyranthes aspera, Sonchus asper* and *Malvastrum coromandelianum*
1.2.2.2b. *Cynodon dactylon, Calotropis procera* and *Euphorbia hirta*
2.1. *Heliotropium europaeum, Calotropis procera* and *Heteropogon contortus*
2.1.1. *Heliotropium europaeum, Calotropis procera* and *Polygala chinensis*
2.1.2. *Heteropogon contortus, Capparis aphylla* and *Setaria glauca*
2.2. *Dodonea viscosa, Justicia adhatoda* and *Pupalia lappacea*
2.2.1. *Mayetenus senegalensis, Ehretia obtusifolia* and *Heteropogon contortus*
2.2.2. *Pupalia lappacea, Poa araratica* and *Rhyza stricta*

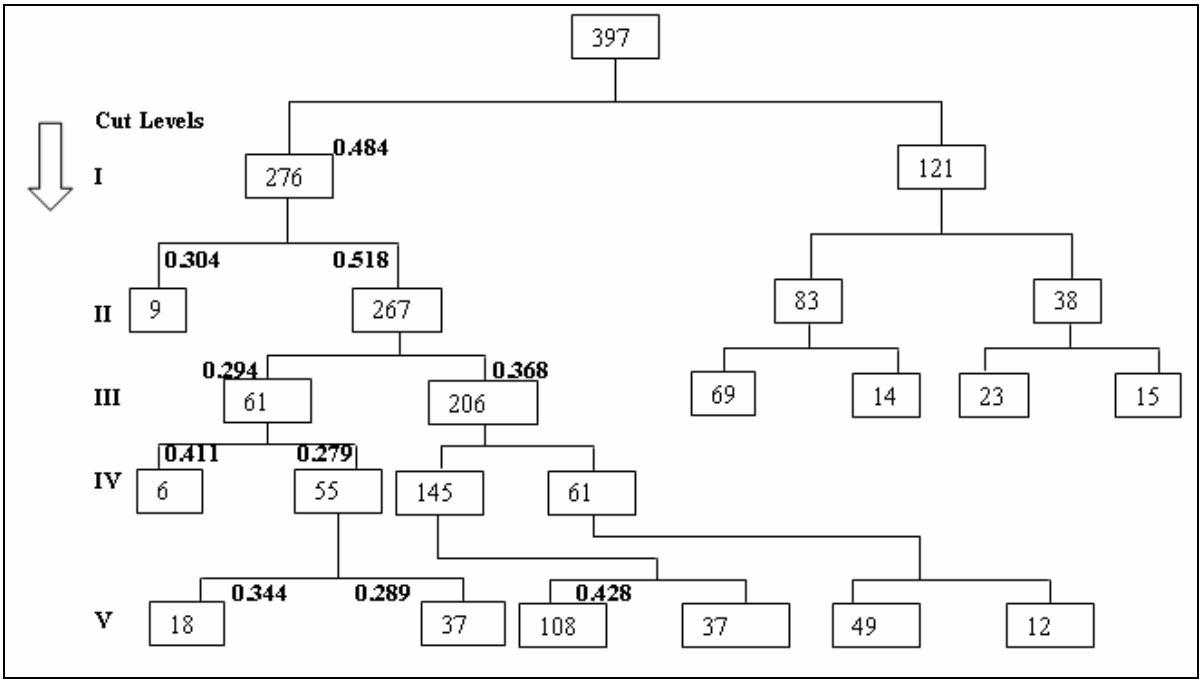

Fig. 2. Vegetation types determined by TWINSPAN. Eigenvalues (in bold) for each division are shown.

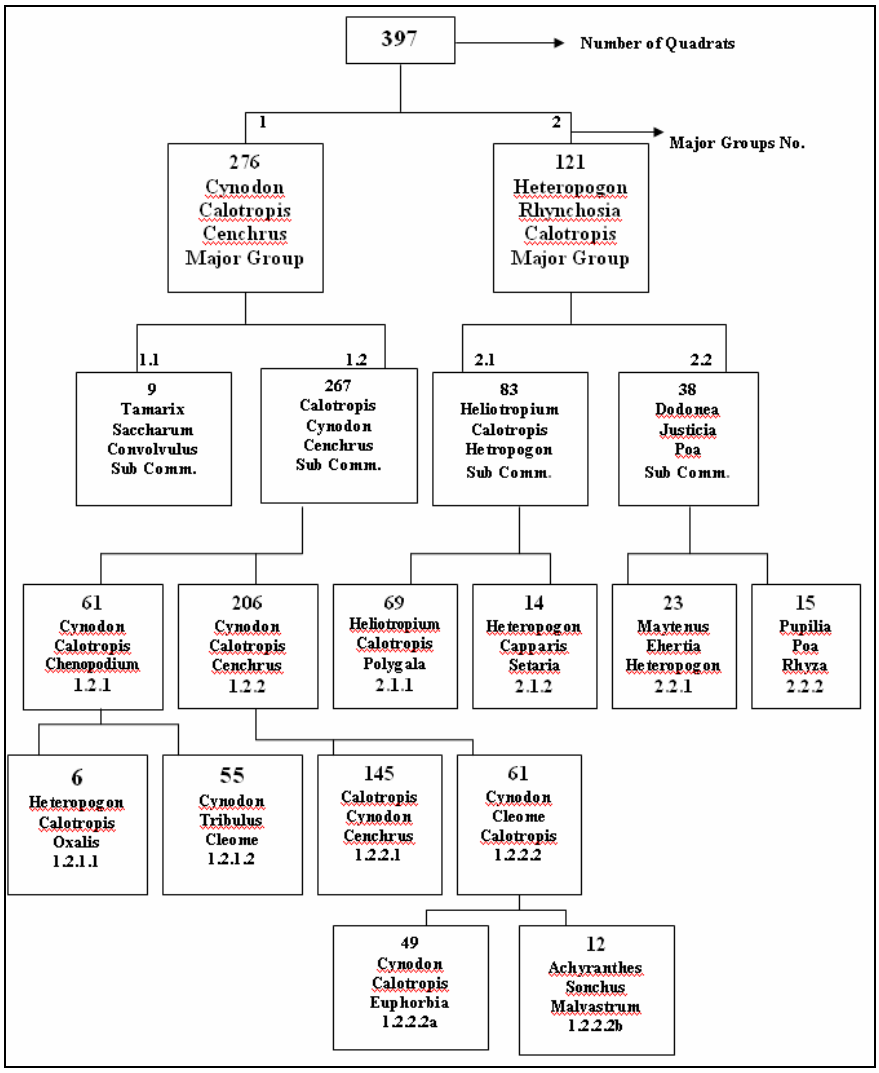

Fig. 3. Major Groups and sub communities determined by TWINSPAN.

1.1. *Saccharum munja, Tamarix aphylla* and *Convolvulus arvensis* group developed on the shoulder of the road i.e. mostly in the border zone near the road. Though this group occurs only in nine quadrats, but the exclusive species exhibits a fairly good cover values e.g. *Tamarix aphylla* 18.2% and *Saccharum munja* 14.3%. *Saccharum munja* is a large tufted grass requiring regular mowing. This group mostly comprises of herbaceous flora including *Euphorbia prostrata, Capparis spinosa, Artemisia scoparia, Launaea procumbens,* etc.

This group mostly occurs in quadrats in the Potohar Region i.e. before Kalar Kahar and Salt Range. Number of species of this group except *Convolvulus arvensis* showed their presence in other groups or sub-communities. *Tamarix aphylla* and *Saccharum munja* are regarded as the most dominant species of this region. The reason for exclusion of these species in further sub-communities seems that *Tamarix* propagates vegetatively and seeds are sterile (www.FAO.orgh/WAICENET/FAOINFO/AGRICUL.doc) while *Saccharum munja* is regarded as grass of river plains, which are situated quite below the motorway. The total number of species in this sub community was nine; hence no further division of this group was made.

1.2. *Calotropis procera, Cynodon dactylon* and *Cenchrus ciliaris* group comprises of same dominant communities as that of major community 1. It is the largest sub community separated by TWINSPAN clustering. This sub community shows its presence throughout the study area both along the shoulder of the road i.e. border zone and towards the verge zone. This sub community comprises of almost 96 species. The flourishing behavior of *Cynodon dactylon* and *Calotropis procera* is supported by the fact that both propagate by seeds (Nasir & Rafique, 1995). The seeds are dispersed by wind and carried along motor vehicles to long distance. *Calotropis procera,* also known as milky weed, is also regarded as roadside weed, whereas *Cynodon dactylon* and *Cenchrus ciliaris* (grasses) grow profusely in wide variety of disturbed habitats (Cillers & Bredenkamp, 2003). Same is the case here; the construction of new motorway provided them a vast area of disturbed habitat. Along with these three dominating species the other major species present in the sub community are *Cleome viscosa, Euphorbia hirta, Bothrichloa pertusa, Conyza bonariensis* and *Launaea procumbens,* all are herbaceous species. Thus supporting the fact that herbaceous flora is well established. An average number of 8 species was recorded per sample plot, of which majority were herbaceous plants.

1.2.1. This sub community, having *Cynodon dactylon, Calotropis procera and Chenopodium ambrosioides,* is situated in plots mostly after crossing salt range towards Lahore i.e. on flat dry areas. These dry patches supporting this group are found after crossing river Jhelum and near Kala Shah Kaku i.e., factory area .The dominants of this community are *Cynodon dactylon, Calotropis procera* and *Chenopodium ambrosioides* here in this community. *Cynodon dactylon, Calotropis procera* occurs together in other communities too, but they are separated due to occurrence of *Chenopodium ambrosioides* here in this community. The species *Chenopodium ambrosioides* is an aromatic herb mostly found along roadsides (Wagner *et al*., 1999). The reason of its occurrence in association with *Cynodon dactylon* and *Calotropis procera* is that it is also dispersed by seeds and vehicles are supposed to be lightweight seeds (www.tncweed.ucdavis.edu/ esodocs.documents.html). Although this group occurs in only sixty one plots but the percentage cover value of dominating species was high for three major species of this group.

1.2.1.1. A very small group occurs mostly around river Jhelum i.e. before and after on a flat area. The common species of the group were *Heteropogon contortus, Calotropis procera* and *Oxalis corniculata.* The quadrats showing the presence of this sub-community were found in an area of comparatively high temperature and low rainfall. Due to this fact *Heteropogon contortus* and *Oxalis corniculata* showed their co-existence. *Heteropogon contortus* is also known as tangle head grass, quite resistant to fire and drought (www.fao.org.ag/AGP/AAAAGPC/doc/Gbase.htm) whereas *Oxalis corniculata* a weed tolerant to high temperature (www.ppws.vt.edu/scott/weed). The occurrence of *Calotropis proc*era in this community again supports the seed propagation of *Calotropis procera* to wider range.

1.2.1.2. The sub community *Cynodon dactylon, Tribulus terrestris* and *Cleome viscosa* showed their presence after the salt range and all along flat verges up to Lahore. The occurrence of *Cynodon dactylon* seems to be ubiquitous (Cillers & Bredenkamp, 1998) whereas *Cleome viscosa,* a spider flower herb, exists near cultivated fields and roadsides (Wagner *et al*., 1999). It is an indigenous species of Asia and sub continent; whereas *Tribulus terrestris* a noxious annual weed (Nasir & Rafique, 1995) grows in dry sandy soils along roadsides and rail roads. The microclimate needed by three dominant species seems to be quite related to each other. *Tribulus terrestris* and *Cynodon dactylon* propagates quickly by seeds and all of them require hot climate for flourishing. Therefore this sub community exists on plots favouring their microclimate conditions and all the plots occur in Region III of the study area that is normally much hot and low rainfall area.

1.2.2. The sub community comprises of *Cynodon dactylon, Calotropis procera* and *Cenchrus ciliaris.* These exist together due to same ecological characteristics and microhabitat requirement. Members of this largest sub community marked their appearance in all parts of study. Thus they are said to be ubiquitous in nature and exist in dry, semi sandy tracks, high temperature and partially disturbed areas. *Cenchrus ciliaris* grass can attain height of 10-15 cm and favors neutralized soil (www.tncweed.ucdavis. edu/esodocs.documents.html). The overall pH of the soil in the study area was also recorded to be 7.0 favoring its growth. Secondly, the existence of *Cenchrus ciliaris* was supported by the fact that it was fire resistant and areas where fire was practically infused, it grows more profusely. These areas were previously subjected to controlled fire by motorway management firm Asianics. The other member of Poaceae i.e. *Cynodon dactylon* commonly termed as devils grass leaves no place to mark its existence as it manage to grow in poor soils and also is drought resistant. Therefore shortage of water supply and hot climate increased its growth. *Calotropis procera* commonly regarded as roadside weed grows vigorously where wastelands or disturbed areas are available. The two species are also considered as indicators of wasteland (www.tncweed.ucdavis.edu/ esodocs.documents.html).

The percentage cover values of these three species were quite high in all the sub communities. The other dominant species occurring in these sub communities were *Bothrichloa pertusa, Sonchus asper, Saccharum munja, Albizia lebbeck, Capparis spinosa, Aeruva javanica, Xanthium strumarium* etc. The sub communities marked the appearance of sub shrubs and trees. These sub shrubs and trees did not cause any allelopathic effect on the grasses as shown by their high cover values.

1.2.2.2. This sub community *Cynodon dactylon, Cleome viscosa* and *Calotropis procera* marked its appearance in Region II & III. The similarity in the ecological amplitude and micro climatic condition in these three species made them grow together. *Cleome viscosa* was found growing near roadsides and cultivated fields (Wagner *et al.*, 1999) whereas *Calotropis procera* is known as roadside weed. Hence their co-occurrence indicates the disturbed soils along motorway. Out of sixty-one quadrats in which they occur mostly belongs to verge zone.

1.2.2.2a. The sub community *Achyranthes aspera, Sonchus asper an*d *Malvastrum coromandelianum* was a very small group which made its existence in only 12 quadrates situated in Kalar Kahar Region. All the three species showed very small % age cover values. Their herbaceous group made a significant growth in waste habitat or area, which was previously occupied for heavy engineering task. Once *Sonchus asper* occupy the area its long taproot is difficult to be removed due to ecological competition (www.plant.identification.co.uk). All these propagate quietly by seeds and require same conditions for their survival.

1.2.2.2b. The diagnostic species of community were *Cynodon dactylon, Calotropis procera* and *Euphorbia hirta*. This community made its appearance mostly in Regions I, II and Region III. The occurrence of *Euphorbia hirta* distinguish this sub community from sub communities 1.2.2, 1.2.2.1, and 1.2.2.2 a. This species *Euphorbia hirta* is shrubby plant, which shows frequent occurrence in Salt Range and prefers dry climatic region. As a whole the milky weed *Calotropis procera* and Bermuda grass *Cynodon dactylon* also prefer dry and hot regions and soils having sandy texture.

The occurrence of *Cynodon dactylon* and *Calotropis procera* and invasion of *Euphorbia hirta* among them clearly indicate the association of *Cynodon dactylon* and *Calotropis procera* throughout the study area and partial invasion of species where the conditions were favorable for third species.

2.1. This sub community of *Heliotropium europaeum, Calotropis procera* and *Heteropogon contortus* is mostly in the areas falling in Region III i.e. towards Lahore. These plots showed highly disturbed soils; fence was broken at some points with a very steep downward slope, and facing run off water from road across the fence. *Heliotropium europaeum* is an annual herb, which is sun loving and highly non-palatable due to toxicity of root and stem. Once it was regarded as one of the common weeds of Europe that propagates by seeds and is used to check soil erosion (www.weedman.horsham.net.au). Existence of *Calotropis procera* indicates highly disturbed land. *Heteropogon contortus* a tufted perennial grass is a quick growing plant. It is highly drought resistant and prefers sandy loam soils. The soil all across the Region III was highly favorable for its growth. However the presence of steep slope downward exhibit a great danger of soil erosion in the area, but the existence of *Heliotropium* seems to be significant enough as it is regarded as highly significant species to control soil erosion. The other species appeared in this sub community having % age cover value of more than 5% were; *Cymbopogon martini, Polygala chinensis, Lactuca sativa, Astragalus psilocentros, Sorghum halepense, Rhynchosia minima, Cynodon dactylon,* and *Digera mutica.*

2.1.1. The exclusive species of this sub community includes *Heliotropium europaeum, Calotropis procera* and *Polygala chinensis.* This sub community differed from the sub

community 2.1 due to occurrence of *Polygala chinensis* in it. All the conditions in 69 quadrats favor the existence of *Heliotropium* as soil erosion controller species in downward slopes and *Calotropis* as wasteland indicator. The other species in this sub community making any impression by their percentage cover values were *Digitaria bicorins* and *Croton sparsiflorus*. All the sample plots exhibiting this sub community were mostly present near Lahore i.e. Region III.

2.1.2. This sub community comprises of *Heteropogon contortus, Capparis aphylla* and *Setaria glauca*. It is a very small sub community occurring just in a few quadrats at the end of study area plots i.e. towards Lahore in Region III. All the quadrats were found in highly disturbed areas. *Capparis aphylla* is a thorny shrub of waste lands (www.survivaliq.com.index) and *Setaria glauca* is annual grass (foxtail) of streams, roadsides and fields (www.npwrc.usgs.gov.resources).

This sub community has appeared only in 14 quadrats, but their co-existence indicates that prevailing conditions in these quadrats were favorable enough for *Heteropogon* (grass), *Setaria* (grass) and *Capparis* (shrub). This mixture of herb-shrub community is indicative of fairly disturbed land due to usage of heavy machinery in the past.

2.2. The sub community *Dodonea viscosa, Justicia adhatoda* and *Pupalia lappac*ea was characterized by dominating shrub species and sparse herbaceous species. The occurrence of *Dodonea viscosa*, an evergreen shrub of sandy soil (www.scs.leeds.ac.uk) and *Justicia adhatoda* an evergreen medicinally important shrub with prostate herbs (www. sbepl.com/index/html) and *Pupalia lappacea* indicate the sandy texture of the areas. The quadrats showing the appearance of this sub community were mostly in Salt Range area and at the start or end of salt range area. The presence of *Dodonea viscosa* in the Salt Range indicates pollution in the area. Due to steep slope in the area the amount of vehicular pollution i.e. lead, zinc, nickel etc was high. And *Dodonea viscosa* is marked as highly resistant to pollutants (www.scs.leeds.ac.uk). The restricted appearance of *Dodonea viscosa* was due to the fact that it requires rocky substratum to appear. Similarly herb like *Pupalia lappacea* invades the vacant spaces between shrubby vegetation and climb upon them sometimes. Shrubs were dominating in this sub community. The other species occurring in these quadrats were ubiquitous *Cynodon dactylon, Calotropis procera, Heteropogon contortus and Poa aratica.*

2.2.1. The exclusive species of this sub community were *Mayetenus senegalensis, Ehretia obtusifolia* and *Heteropogon contortus*. This small sub community marked in 23 quadrats was found mostly in plots between river Jhelum and river Chenab area. The interesting feature of this sub community was that in all the quadrats, the adjacent area was used for wheat cultivation and all these quadrats were present in the verge zone i.e. away from the road.

The two shrubby or small tree species of *Mayetenus senegalensis and Ehretia obtusifolia* were provided with adequate water and to some extent fertilizer from the adjacent fields to grow vigorously and maintaining good growth rates. The grass *Heteropogon contortus* might have invaded the area due to quick propagation and good availability of water although it is resistant to short term drought (www.tncweed.ucdavis.edu/ esodocs.documents.html).

2.2.2. This is a fairly small sub community marked by the diagnostic species like *Pupalia lappacea, Poa araratica* and *Rhyaza stricta.* This sub community appeared in the same study area between river Jhelum and river Chenab. All the adjacent areas of the study

area were having wheat cultivation. *Pupilia* (prostate herb) *Poa* (grass) and evergreen shrub *Rahyza* were grouped together because of some ecological requirements. The interesting feature of this sub community was that majority of the quadrats of this sub community were present on the border zone i.e. near the road.

Discussion

Despite the large number of species recorded on the road verges in the study area, the number of frequent species is not very large. There is a limited number of species that show dominance throughout the study area. It indicates wide ecological amplitude of the dominant species of road verges.

Since the classic studies of Whittaker (1956) & Bray & Curtis (1957), plant ecologists had quantized the distribution of plant species along complex environmental gradients the vegetation patterns are often correlated with patterns of resource variation and resource gradients has been well established in vegetation science (Gleason, 1926; Whittaker, 1956, 1962; Smith & Huston, 1989; Rentch *et al*., 2005; Ahmad *et al*., 2009 and Jobeen & Ahmed 2009). Different plant species or groups of species might have different resources use strategies, physiologies and competitive abilities and thus may be segregated into different functional groups. Classifications and ordinations can provide more detailed and more comprehensive information on the distributions of vegetation types.

In the present work an attempt has been made to describe the vegetation types and their distribution on the M-2 in the study area. The TWINSPAN divisions reflect the range of floristic diversity, the relative frequency of individual species and comparative abundance of different species. In the road verges communities and sub communities, there was a general dominance of a few grass species. Out of total 227 species recorded in the study area, 9.2 % were members of family Poaceae. This high degree of occurrence of *Cynodon dactylon* was supported by the fact that it forms a complete cover on the ground where it grows (Ali *et al*., 2004). Similarly in a study on roadside vegetation in France, Heindl & Ullmann (1991) described *Cynodon dactylon* as a species, which is adapted to mechanical impact and is therefore able to suppress the growth of other plants, forming a large monotypic stands in the process. Similarly roadside plants are used to monitor soil pollination (Pirzada *et al*., 2009).

Although grass species dominated having high cover and frequency values, but in certain areas *Calotropis procera* took over the dominant role. On the border zone (near the road) vegetation cover is slightly low. In general most of the observations in the current study area were in accordance with studies on roadside vegetation abroad (Ullmann & Heindl, 1989; Heindl & Ullmann, 1991; Wilson *et al*., 1992; Ullmann *et al*., 1995 and Cillers & Bredenkamp, 2000). Most of the communities described in this study are situated on so called transition areas between the urban environment and natural, rural areas. Pysek (1992) argued that transition zones between human settlements and the surrounding rural areas show many features of ecotone diversity, and higher plant species richness. The occurrence of *Parthenium hysterophorus* among these species sharing a maximum cover value also supports the fact that disturbance frequently helped in the spread of invasive exotic plants (Larson, 2003).

This study forms the basis for further studies on the vegetation dynamics of roadside verges in Pakistan. The existence of different plant communities, which were classified and described in this study, must be taken in consideration in the management of roadside verges.

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(Received for publication 6 October 2009)