Ecological Assessment, Conservation Status and Restoration Strategies for *Nannorrhops ritchiana* (Griff.) Aitch. in the Agency of Bajaur, FATA, Pakistan

Master of Philosophy in Plant Sciences

(Plant Ecology and Conservtion)

By

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APPROVAL CERTIFICATE

This is to certify that the dissertation titled **"Ecological Assessment, Conservation Status and Restoration Strategies for *Nannorrhops ritchiana* (Griff.) Aitch. in the Agency of Bajaur, FATA, Pakistan"** submitted by **Abdullah** is accepted in its present form by the Department of Plant Sciences, Quaid-i-Azam University Islamabad, Pakistan as satisfying the thesis requirement for the degree of Master of Philosophy in Plant Sciences.

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DECLARATION

I hereby declare that no part of this thesis has not been previously submitted to this or any other University as part of the requirements of any degree. The contents of this thesis are the results of my own work unless otherwise acknowledged in the text or by reference. The research work presented in this thesis was carried out by me in the laboratory of **Plant Ecology and Conservation,** Department of Plant Sciences, Quaid-i-Azam University Islamabad.

Abdullah

DEDICATIONS

Dedicated
To The
Mazri Palm
(Nannorrhops ritchiana),
a Source of Livelihood
for Thousands
of Poor People Around the
Globe

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LIST OF ABBREVIATIONS

%	Percentage
AOO	Area Of Occupancy
Ca	Calcium
CA	Cluster Analysis
CANOCO	Canonical Community Ordination
CCA	Canonical Correspondence Analysis
DCA	Detrended Correspondence Analysis
EC	Electric Conductivity
EN	Endangered
EOO	Extent Of Occurrence
GIS	Geographic Information System
GPS	Global Positioning System
ISA	Indicator Species Analysis
IUCN	International Union for Conservation of Nature
IV	Importance Value
IVI	Important Value Index
K	Potassium
Mg	Magnesium
N	Nitrogen
P	Phosphorous
P*	Probability Value
SAC	Species Area Curve
TWCA	Two Way Cluster Analysis

Nannorrhops ritchiana in Batai Zerako Village Alizoo Utmankhel

ABSTRACT

Nannorrhops ritchiana (Griff.) Aitch (Mazri Palm) is a species of palm family or Arecaceae, distributed in Iran, Afghanistan, Pakistan, Oman and Arabia. The current study was aimed to study various association formed by *Nannorrhops ritchiana* with associated flora under various edaphic and climatic factors. Conservation status of the species was assessed with the help of IUCN (International Union Conservation Nature) red list categories and criteria's. Ecological data was analyzed with multivariate statistical techniques e.g Cluster Analysis (CA) and Two Way Cluster Analysis (TWCA) Indicator Species Analysis (ISA), Canonical Correspondence Analysis (CCA) and Detrended Correspondence Analysis (DCA) were carried out using software's PCORD version 5 and CANOCO version 4.5. Total of 70 associated plant species belongs to 27 families were collected. Among these herbs were 89% and shrubs were 11%. Poaceae with 15 species, Asteraceae and Lamiaceae with 8 species each were the dominant families. Through CA and TWCA all associated plants were grouped into four associations. These were (1) *Aerva javanica- Spergularia diandra -Dodoneae viscosa* (2) *Erodium cicotarium-Tribulus terrestris-Gymnosporea royleana* (3) *Acrachane racemosa -Cyperus rotundus-Gymnosporea royleana* (4) *Cymbopogon martini-Salvia moorcraftiana-Periploca aphyla* associations. It was observed that high Magnesium, Sodium and Grazing pressure were the important edaphic and environmental variables. Extent of occurrence (EOO) of the species was 42.2 Km^2 less than 5000 Km^2 and area of occupancy (AOO) was 28.2 Km^2 less than 500 Km^2. Through IUCN criteria B the species was declared as Endangered (EN), B1 bc (i, ii,iv) +B2 bc (i,ii,iv). It was concluded that the Magnesium (Mg), Sodium (Na) and Grazing pressure (Gp) play important role in the determination of vegetation structure, association formation and its particular indicators. This study could further be used in evaluation of vegetation and conservation of threatened flora.

Chapter **1**

INTRODUCTION

1.1 HISTORY OF ECOLOGY

Ecology is a multidisciplinary science deals with the study of interrelationship of living organism with each other and their environment. One of the French zoologist Geoffroy Saint-Hilaire had proposed another term ethology. It is the study of relationship within the family, society or community (McIntosh 1985). Another English naturalist St. George Jackson Mivart in 1886 coined the term *hexicology*. It can be defined as the relationship of organisms with each other and their environment (McIntosh 1985). Although the original term of ecology was used in 1886 but it was not extensively used till the end of 1900 century. In 1913-1915 word ecology became an institutionalized term when the British and American Ecological Societies came into being respectively. The term "Ecology" coined for first time in 1866 by a German zoologist, Ernst Haeckel. The word ecology comes from the Greek word "Oekologie" which is the combination of two words "oikos", meaning household, home or place of living and "logy" means to study. Thus ecology is the study of living things with their environment. Ecology is further divided into sub branches such as synecology, autecology ecology, conservation ecology, landscape ecology, ecosystem ecology, physiological ecology or ecophysiology etc. Many scientists defined the term Ecology in different ways some of them are given with their definition in Table 1

Table 1.1 some common and Important definitions of ecology

S.No	Scientist's name	Year	Definition
1	Clements	1916	Ecology deals with science of community
2	Charles Elton	1927	Scientific natural history
3	Victor Shelford	1937	It is a branch of general physiology, deals with the organism as a whole
4	Eugene P. Odum	1953	It deals with function as well as structure of an ecosystems
5	Karl Friederichs	1958	The science of the environment
6	Andrewartha	1961	The scientific study of the distribution and abundance of

			animals
7	Smith	1966	Ecology deals with the study of structure and function of nature
8	Krebs	1972	Ecology is the study of interrelations of organisms that determine the distribution and abundance of organisms
9	Emlen	1973	It deals with the adaptations of the individual to their environment
10	Ehrlich and Roughgarden	1987	Relationship among organisms and their biological and physical environment

(Ahmed and Shaukat 2012, Kormondy 2012)

Population ecology also known as autecology is the study of the structure and subtleties of a population which comprises of a group of interrelated organisms of the single species that occupies a specific area (Hannan and Freeman 1977). Population is a group of individuals of the same species that live together in a region (Sarkar and Plutynski 2010). Populations can be characterized as local which is a group of less number of individuals occupying a small area or met which is a group of local populations linked by disbanding members (Begon et al. 2009). The demographic structure of a population is a key factor which is characterized by the number of individual members present at each developmental stage of their cycle to identify whether the population of a specific specie is growing, shrinking or remain constant in terms of its size (Sutherland 1996). In current research work we will discussing population as well as synecology of *N. ritchiana*

1.2 ROLE OF SOIL IN DISTRIBUTION OF PLANT SPECIES

Soil structure, texture and various nutrients present in soil play significant role in the distribution of plant species. Numbers of researchers discussed that soil and various nutrients present in soil are considered to be strong environmental variables for the distribution of plants species. The sociability of plants is closely linked to the structure of soil of the region because nutrients are mandatory for growth purposes and provided by soil. Richness of flora and in relation with soil have been interpreted in number of grasslands, tropical habitats as well as in Savanna (Khairil *et al.* 2014). In ecological studies soil play role of backbone that's why a considerable number of papers are available on soil and its properties. Soil physico-chemical properties are directly

related with normal properties of soil which are considered important drivers in the distribution of plants (Marini et al.,2007).

Physio-chemical properties effects on the fruit as well as on seed production of plants. Role of Nitrogen, (Abbas and Qaiser 2011a) Potassium and Phosphorus (P) in growth, conservation and regeneration of plants are well understood and documented (Cristofoli et al. ., 2010). Species composition almost varies slope to slope due to various resource in which availability of water is obvious (Badano et al., 2005, Gong et al., 2008). Furthermore to observe diversity in vegetation due to various soil factors and properties the species occur on south facing slopes have maximum resistance to stresses (Bennie et al., 2006). Soil nutrients have been considered crucial factors for phyto-diversity (Zechmeister et al., 2003).

According to (Khan et al. 2017) being an environmental factor soil affect topography, climate, microbial flora and natural materials. Conversion of forest, grassland and pastures into agricultural fields and vice versa is a influencing phyto-diversity and terrestrial ecosystem. Change in chemical as well as in physical properties of soil well documented and enduring effects on nutrients, pH and texture etc of the soil (Lauber *et al.*, 2008). Soil pH, Nitrogen and Phosphorous are appeared to be strong environmental drivers of the plant communities (Sánchez-Rodrıguez et al., 2002). Degradation of soil has great impact on the distribution as well as on the composition of plants and its communities. It relies on the rate of vegetation fragmentation and degradation in addition which is affected by climatic condition and changes through anthropogenic activities (Langbein and Schumm, 1958). In those zonation's of forest where soil cover is shallow has low moisture, slow rate of regeneration and growth of vegetation can be eroded easily with floods (Kosmas and Danalatos, 1994).

The reduction in vegetation cover cause desertification in that specific area. Elevational gradient also effects on the soil such as mentioned by in sub-arctic, boreal and tropical forest The soil of tropical forest, sub-arctic and boreal forests are influenced by (Schuur and Matson, 2001, Fisk et al. ., 1998). Soil is a great source of various metals and minerals for plant species. Many of these elements are very harmful and poisonous and cause different disease in plants and its consumers. Such type of elements which cause disease in living organism mostly comprises of heavy metals.

1.2.1 *Heavy metals*

The word heavy metal is a broad term for all those metals which has toxic effect on the biotic and abiotic components of the environment at a very minute concentration (Lenntech 2004, Duruibe et al. 2007). All those metals and metalloids are categorized under the category of heavy metals that have atomic density greater than $4g/cm^3$. Heavy metals toxic and poisonous nature

can be determined through their chemical properties (Duffus 2002). Environmental pollution caused by heavy metals are a common and serious problem of the present world caused by anthropogenic activities. Common heavy metals occur in our environment are Lead (Pb), Mercury Ag, ,Copper (Cu) , Cadmium, Chromium (Cr), Arsenic (As), Nickel (Ni), Zinc (Luczaj et al. , Luczaj et al. 2016) and Silver (Ag) etc.

1.2.2 *Sources of Heavy metals*

1.2.2.1 Natural source

Volcanic eruptions are considered to be the most important natural source of heavy metals (Seaward and Richardson 1989) reported that Pb, Al, Ni, Zn, Hg, Cu etc release in maximum level with harmful and toxic gases during volcanic eruptions. In desert wind dust arises has high levels of Fe low level of other heavy metals i.e Mn, Zn, Ni, Cr, Pb etc (Ross 1994). The decomposition of leaves and stem of natural vegetation also release heavy metals into the soil. It occur naturally in small amount in soil. From soil bodies it may enter into water bodies through the process of rocks leaching, airborne dust, forest fires and from litter layer of natural flora (Nguu et al. 2011) Erosion of soil may be due to wind or water cause heavy metal pollution (Taiwo et al. 2011).

1.2.2.2 Anthropogenic sources

Human population increases very rapidly. The fast urbanization and industrialization are the main cause of heavy metal pollution. Mining, burning of coal, textile formation and nuclear wastes are some common anthropogenic activities that increases the level of heavy metals in the environment. Soil and aquatic ecosystem have maximum quantity of heavy metals than atmosphere (Gillman et al. 2014). Petroleum combustion, Textile, paper, nuclear power stations and plastic processing plants effluents comprising metals such as Cr, Cd, Cu, Ni and Ag. Organic as well as inorganic fertilizers containing heavy metals such as, Pb, As, Cd, V and Hg (Yanqun et al. 2005). Soil contamination take place by the discharge of sewage sludge with high concentration of Pb, Cu, Zn Cr, and Cd (Passariello et al. 2002, Nagajyoti et al. 2010). Textile industries add maximum quantity of heavy metals pollution into water bodies. Staining process in textile of cloths is a main source of these heavy metals.

These are mostly originating due to staining process, which is a major process in such textile industries. The compounds used in staining process have maximum amount of Cu, Cr, Ni and Pb highly toxic and cancerous elements. Our micro and macro biota of agricultural soil as well as in aquatic ecosystem highly disturbed by heavy metals discharged from various industries. Uptake

of these heavy metals take place in plants in ionic form and transfer to animals by the means of food chain (Wintz et al. 2002). The effect of heavy metals toxicity appears in plant bodies based on the nature of accumulation and area.

1.3 CONSERVATION

Plants have a significant role in provision of various ecosystem services such as food, shelter, poisons, clothes, oils, fuel wood, dyes etc. Unfortunately in current era our flora facing number of threats i.e. habitat fragmentation, extend of invasive, habitats destruction, nonstrategic and unsustainable agricultural and forestry practices, urbanization, over-exploitation, pollution, diseases and over collection by local herders for various purposes. Furthermore change in climatic factor is another serious and alarming factor for the conservation of flora and fauna (Thomas et al. 2004, Jan and Ali 2009). Nowadays plant extinction as on alarming rate because due to the result of anthropogenic activities extinction of one species occur daily. According to (Akeroyd 2011) this rate of plant extinction is very fast and it is considered to be thousand to10 thousand times faster than that occur naturally. If this trend of extinction remains constant, about 60 thousands-1lakh plant species in coming future may disappear (Bramwell 2002). The extinction crisis of species are recognized to be the highly severe for the survive mankind. Furthermore, conservation of plants and animals is the moral duty of human being in order to smoothly running of different ecosystems on the surface of earth.

Evaluation through IUCN categories and Criteria's is the procedure of assigning different plant and animal species in a threatened category. Mostly those species are categorized which are on the threshold of extinction. In the start of 1960s IUCN started red listing for first time. Obvious change was observed in 1994 when for the first time new quantitative criteria were used (Baillie et al. 2004). IUCN red list for threatened flora and fauna species and IUCN red list for ecosystem were established to show complementary aspects for its erosion and recovery (Rodríguez et al. 2015). Red list of ecosystem was established to help in the risk assessment of ecosystem through evaluating their peculiar or distinguished biota and environmental processes. IUCN led a significant model shift among the conservation community when it assumed quantitative criteria and threshold for threatened biota extinction risk categories designation (Mace and Lande 1991, IUCN 2017). IUCN red list become basic source of data for the conservation status at global level of animal as well as plants species (Collar 1996, Lamoreux et al. 2003, Brooks et al. 2006).

Fig. 1.1: *Nannorrhops ritchiana* uprooted by porcupine (*Hystrix indica*) in study area Bajaur

1.4 IUCN RED LIST CATEGORIES AND CRIETERIAS

1.4.1 *Extinct*

A taxon is categorized to be in the category of Extinct when the last individual has been died without of any reason able doubt. A taxon is considered to be extinct when in suitable season and its known/expected habitat after an exhaustive survey failed to record a single individual.

1.4.2 *Extinct in the Wild*

A taxon is recognized to be Extinct in the Wild when in wild its population has been ceased and only survive in cultivated for outside its natural or in past range. A taxon is categorized to be Extinct in the Wild when in suitable season and its known/expected habitat after an exhaustive survey failed to record a single individual.

1.4.3 ***Possibly Extinct***

A taxon is considered to be Possibly Extinct when the exploration in its local habitat have failed to record a single individual, but for which there is a little chance that its individual may be found extant after exhaustive survey.

1.4.4 ***Threatened***

The term threatened collectively used for categories of Critically Endangered (CR), Endangered (EN) and Vulnerable.

1.4.5 ***Critically Endangered (CR)***

A species is recognized to be CR when it is proved from the best available data that the taxon qualify for any of the criteria from A to E for CR. Furtherly considered to be under high risk and extinct to be in near future in its wild habitat.

1.4.6 ***Endangered (EN)***

A species is considered to be EN when on the best available evidences qualify for any of the criteria A to E for EN and facing in the wild a very tremendous risk of extinction.

1.4.7 ***Vulnerable (VU)***

A species is considered to be VU when the best available data show that the taxon qualify any of the A to E criteria for VU.

1.4.8 Near Threatened (NT)

A species is considered to be NT when it is evaluated on any one of the criteria A to E and but now does not qualify for any of these, but is likely to qualifying for any of the threatened category in near future. The species should be close to qualifying for VU category.

1.4.9 ***Data Deficient (DD)***

A species is considered to be DD when the available information is inadequate to process a direct/indirect assessment of risk which it face and causes its extinction based on its status of population or distribution. Biology of the species in this category may be well studied and known, but sufficient data unavailable on its distribution and abundance.

1.4.10 ***Not Evaluated (NE)***

A taxon is considered to be NE when it is has not evaluated against of the IUCN criteria. Currently this category applies to most of the world known taxa. In Pakistan many author contributed the IUCN red list.

1.5 CONSERVATION STUDIES ON THE NATIVE FLORA OF PAKISTAN

Pakistan has a unique altitudinal ranges from sea level to the 2nd highest peak on Earth K2 (0-8611 m). The country also having unique temperature extremes ranges from below 0 to 52°C in the high glacier mountains and Sibi plain respectively. Annual mean rainfall ranges from 50mm to 2032 mm at Nok Kundi in Baluchistan and in Kashmir uplands where monsoon rains occur (Ali 1978). These major differences in temperature, elevation, precipitation and phytogeographical regions support a great diversity of plants. On the basis of these various factors the territory of Pakistan was divided into five distinct phytogeographical provinces such as Southern Iranian Province, Northern Baluchistanian Province, Saharo Sindian province, Western Himalayan Province and Tibetan Province (Takhtajan 1986). This region having a great potential to support a great phyto-diversity. About 6000 plant species have been reported from Pakistan. Out of these 6000 plant species about 400 taxa are endemic to this region. Number of authors have been contributed to the IUCN Red list and evaluated plant species according to the Red List Categories and Criteria. Six species were classified in the category of critically endangered e.g *Asperula oppositifolia* subsp. *baltistanica*, *Androsace* russellii, *Astragalus clarkeanus*, *Haplophyllum gilesii, Tanacetum baltistanicum* and *Berberis pseudumbellata* subsp. *Gilgitica* from Gilgit and Baltistan (Alam and Ali 2010). In Chitral *Hedysarum alii, Hedyasarum volkii* Rech. f., *Hedyasarum brahuicum* Boiss. and *Hedyasarum sericeum* M. Bieb. were classified in the category of critically endangered (Haidar and Qaiser 2018). *Acacia nilotica* subsp. *Hemispherica,* (Abbas et al. 2013), *Gaillonia chitralensis* (Ali and Qaiser 2010b), *Convolvulus scindicus* (Abbas and Qaiser 2011a) and *Silene longisepala* (Ali and Qaiser 2011) were classified in Endagered category.

N. ritchieana is also one of those plant species that have great potential and share in the economy of the local inhabitants of the research area. They use *Nannorrhops* plant for fuel, fencing, construction, fibers and in the processing of other cultural items such as ropes used in bed stead, baskets, cages, hot pots, hand fans, shoes etc. To fulfill all these requirements they collect its leaves from wild habitat. Unplanned cutting of leaves is a main eroding factor for its population. In 1953 when Pakistan was a nascent country Government of Pakistan passed an act on the conservation of *Nannorrhops* namely "Kohat Mazri Control Act 1953" (http://kp.gov.pk/page/the-kohat-mazri-control-act-1953/page-type/rules) in this act they form laws for the conservation of *Nannorrhops* in Kohat division. Recently people of indigenous

communities use its leaves as they use in past for livelihood as well as other purposes. They form various handicrafts and utensils from its leaves.

In Mohmand agency (KHALID 2017) categorized Mazri palm in the category of endangered through IUCN categories and criteria (IUCN 2007). They also reported that for the past few decades species number of *N. ritchieana* has been decrease. Possible reason for its population destruction is its usage in huge amount for processing various handicrafts. In Mohmand agency all local communities are involved in its population destruction in general while Utmankhel tribe in special. In recent study an effort has been made to classify and evaluate the conservation status of *N. ritchieana* in the agency of Bajaur according to IUCN Red List Categories and Criteria (IUCN 2017). Field studies were carried out in 2017 and 2018. Population size, mode of reproduction, Quality of habitat, habit, phenology, life form, geographical distribution, associated flora and ethnoecological usages were studied in its native habitat.

1.6 DESCRIPTION OF TARGET PLANT SPECIES

Classification

Accepted scientific name :	*Nannorrhops ritchieana* (Griff.) Aitch
Kingdom	Plantae
Phylum	Tracheophyta
Class	Liliopsida
Order	Arecales
Family	Arecaceae (Palmae)
Genus	*Nannorrhops*
Species	*Nannorrhops ritchieana* (Griff.) Aitch
Synonyms *Nannorrhops*	*Chamerops ritchieana* Griff, *Nannorrhops arabica* Burret, *naudiana* Becc. *Nannorrhops stocksiana* Becc.

***Nannorrhops* H.Wendl.**

Distinguish characters

It is a gregarious shrubby and hermaphroditic fan palm. Leaf of *Nannorrhops* is distinguished that it lacking hastula with dichotomously branched erect stem and supra-foliar compound inflorescence

General Description

It is unarmed, shrubby, hapaxanthic, moderate, clustered, bisexual palm species.

Stem

Nannorrhops has mostly prostrate or erect stem, axillary stems in prostate stems while dichotomous in erect stems.

Leaves

Induplicate leaves, marcescent, briefly costapalmate; below and opposite the petiole sheath splitting, brown, petiole elongated, superficially channeled adaxially, abaxially rounded, leaves having no hastula; leaf blade divided regularly into segments, glaucous, segments are single fold, or divided by abaxial splits furtherly, abaxially midribs are very prominent, transverse veinlets obscure.

Inflorescences

Inflorescences are of compound nature found on the top of leaves. It is further divided into branches equivalent to the inflorescence of pleonanthic palms which occurs axillary. It is subtended by a leaf has reduced blade or by tubular shape of bracts and divided to the fourth order; tubular nature prophyll, 2-keeled; 0 to several peduncular bracts, bracts similar subtending first order tubular branches, pointed tips, each branch of first-order with a basal, tubular, two keeled, empty prophyll; subtending bracts second-order branches tubular; rachillae produced transparent tubular bracts, variously tomentose, each subtending a group of flowers.

Flowers

Flower pedicellate, in a compacted cincinnus of 1–3 (–7) flowers, each single flower producing a small tubular bracteole; thin calyx, at the base tubular with three triangular lobes; corolla with a short size stalk like base and three of distinct lobes, imbricate in the proximal 2/3, valvate in the distal 1/3. Six stamens, distinct, the antesepalous comprises of free filaments and at the base adnate to the petals. Filaments are mostly of awl shaped and at the tip inflexed. Anthers elongate, versatile, latrose; 3 carpels, connate except at the very base, ovary divided into 3 distinct grooves, single style, stigma differentiated scarcely, anatropous ovule ventrally and basally attached.

Pollen

Pollens of *Nannorrhops* are ellipsoidal, mostly asymmetric slightly; aperture a distal sulcus; tectate ectexine, foveolate-reticulate or reticulate, psilate or scabrate aperture margin; infratectum columellate and longest axis in size 30–39 μm.

Fruit

Fruit sub globose to ellipsoidal with a single seed, stigmatic and remains basal; smooth epicarp and fleshy mesocarp and thin endocarp. Seed usually globose to ovoid, with very thin grooves

equal to the rapheal bundles, hilum on the base, homogeneous endosperm, mostly with a small hollow in the center and basal embryo. Remote-ligular type of germination and undivided eophyll.

Cytology: 2n = 36.

Biology

It occurs usually in areas having semi-desert like characteristics where the water table is not much deep, but tending to avoid subtropical coastal habitats within its range, its distribution ranges from 900m to 1800 m altitude.

1.7 RESEARCH SITE DESCRIPTION

The research area Bajaur agency is a hilly terrain of federally administrated tribal areas (FATA). It is located in northern part of Pakistan (HAQ et al. 2015). Bajaur agency is bordered by the district of Malakand to the south east, Dir to the North and North-East, from the south by the agency of Mohmand and on the West and North-West sharing fifty two Km long border on the historical Durand line with the Kunar province of Afghanistan (MA 1999). Bajaur is the smallest agency of FATA in terms of area while largest from all agencies in population. In 1960 Bajaur agency was declared a subdivision of Malakand. In 1973 Bajaur become an independent agency. In 2018 government of Pakistan passed a constitution and merged total agencies and FRs of FATA in Khyber Pakhtunkhwa

1.7.1 ADMINISTRATION

The Agency of Bajaur comprises of seven Tehsils i.e, Khar, Barang, Mamund, Chamarkand, Utmankhel, Salarzai and Nawagai. Each tehsil considered is a separate administrative unit. When the areas were governed by British, the administrative control of the tribal areas were under the control of central government. In 1947 when Pakistan came into being foreign affair ministry take the control of these areas. Pakistani government appointed political agent (PA) for each agency as a ruler.

Fig. 1.2: Showing administration of Bajaur Agency

1.7.2 *People of Bajaur Agency*

The area is called Bajaur because a Pashtun tribe Bajauri is living here. Bajauri people also living in the Kunar province of Afghanistan, Mardan, Peshawar and Swabi. Pashto is the local language spoken in the study area.

1.7.3 *Physiography*

The topography of Bajaur agency comprises on mountains and valleys. There are five main hilly ranges in the study area. The Arang and Barang mountainous ranges occurs on the South and South east up to Panjukora river towards Malakand district while the Salarzai, Mamund and Charmang ranges occur along Durand line towards Afghanistan. These hilly terrains comprises of rough and steep slopes. K-More also known as three peak mountain is the tallest peak of the agency situated in the hilly range of Barang.

1.7.4 *Rivers and Streams*

Various streams originated from various zones of Bajaur Agency. These streams are locally known as Ruds. Mamund stream originate from Mamund area and flows from the various area of the ex-state of Khar. In Past the Mamund stream origination are was Kharki while in present the stream originates near Sesai Afghan refugees camp due to variation climate. The total length

of the stream is about 13 Km from Sesai camp to Musa Kas where it joins with Nawagai stream. Nawagai stream mainly originate from Zorbandar and its adjacent areas and flows parallel along the various areas of Utmankhel and joins with Mamund stream at Musa kas near Government Post Graduate College Khar Bajaur Agency. Nawagai stream is about 15 Km in length of from its point of origination to Musa kas. Salarzai stream it originates from two points (i) From the mountains at Afghan border Gabar spring in Salarzai valley. These both streams joins near Pashat and form a single large stream. The Salarzai stream meets with Mamund and Nawagai stream at Jar Mulla Kalay and form a large stream or small river. All of these streams finally passes from the territory of Bajaur agency and finally flows into Panjkora river. The other two streams occur in Barang and Arang areas are small than the other above mentioned streams. The Barang stream originates near Mian Khan Dara and flows down towards Tangoray area and finally flows in Punjkora river. The Arang stream originates from Tawheedabad (Kharmotay) area and flows down in Naranj area and finally in Punjkora river. In Bajaur agency there is no big river that originate from the area. The Panjkora river enters in Bajaur agency near Zullam bridge and flows along the steep and rough hily terrains of Arang and Barang.

1.7.5 *Agriculture*

Agriculture is a main source of economy and development in several countries such as Pakistan. The economy and development of Bajaur agency also based on agriculture. Crops cultivation such as wheat, maize, rice, barley, mustard, lentils, tomato, shimla chilies, brinjal, garlic, onion, cauliflowers, radish and turnips etc are the main Rabi and Kharif crops grown in the area. Mamund, Nawagai, Salarzai, Barang and Arang streams play an important role in the irrigation of study area. Tube wells and dug wells are also important source of irrigation.

1.7.6 *Climate of the Study area*

Climatic of the study area reach to extremes both in winter and summer. Annual mean temperature in summer season ranges from 23^0c to 36^0c in the plains. In winter season the average temperature ranges from 5^0c to 10^0c. December and January are the coldest months of the year. Maximum rain fall take place in the month of February and March in winter and July and August in summer. Annual mean precipitation is about 375mm.

1.7.7 *Literacy in study area*

Bajaur Agency is a remote area of FATA. Considerable number of peoples are uneducated due to various reasons e.g unavailability of resources and institutions, poverty etc. Recently people giving priority and attention to education and sends child's out of the agency for graduation and postgraduation. The total detail about literacy were given in the table

Table 1.2 Showing detail about literacy in Bajaur Agency

	Institutions			**Enrollment**			**Working Teachers**		
	Boys	**Girls**	**Total**	**Boys**	**Girls**	**Total**	**Male Total**	**Female**	
Primary	333	157	490	92613	40762	133375	848	326	1174
Middle	28	20	48	3567	1365	4932	116	59	175
High	29	8	37	14249	1792	16041	357	50	407
High Sec.	1		1	273	273		14		14
Degree College	3	1	4	2060	144	2204	75	16	91
Community	27	26	53	1579	3277	4856	12	38	50
Agency/FR Total	432	212	650	115586	47340	162926	1434	500	1923

1.7.8 *Ethnography*

Bajaur agency mainly populated by two big tribes namely Utmankhel and Tarkanri. The Utmankhel tribe lies in the south east towards Malakand agency while the Tarkanri tribe lies in the Northwest towards Afghanistan. The Tarkanri tribe having higher population than Utmankhel tribe but the Utmankhel tribe has covered larger area than Tarkanri tribe. Both of the tribes were further divided into sub tribes. Utmankhel tribe, comprising of Alizai (Shinkey, Saramena & Batai) Shamozai (Arang, Lartras and Bartras), Aseel (Barang and Aseel targhao), Gharshamozai (Sharbatai, Gadamar, Pendakhel targhao and Totakan) Mandal (Toop Mandal, Manrogay). The Tarkanri tribe occupies the Chamarkand, Charming, Mamund, Nawagai, Salarzai and Extate of Khar Tehsils. When Pakistan government take the control of the

1.7.9 *Nawabi and Malaki systems*

Before the independence of Pakistan the Tarkanri tribe of Bajaur agency was ruled by Nawab of Khar. Main center of his government (capital) was Khar. He formed Khans and Maliks for various valley and villages such as Pashat Khan for Salarzai, Nawikale khan for nawikale and adjacent areas, Umari khan, Lar Khalozo, Barkhalozo, Tarkho Maliks etc. All of Khans and Maliks ruled these valley and villages under the governance of Khar Nawab. In current era the Nawabi system become perished while the Khan and Malik systems remains. On the other side in the Utmankhel tribe there is no system of Khans and Maliks.

1.7.10 *Population of Bajaur agency*

Bajaur agency is the smallest agency in FATA on the basis of area while largest from all agencies in case of population. According to census in 1972 its population 364,050 in 1981 it is 289,206 in 1998 595,277 and in 2017 1093684 with an average growth rate of 3.25 percent per annum since 1998-2017 (Anonymous 2017).

1.7.11 *Metrology*

The season of winter ranges from Nov-Mar. Season of winter in the area is very cold sometimes temperature goes to freezing point. Average temperature in winter is from 10-15^{0}C. Season of spring starts from the mid of the month of Mar and ends till the end of Apr. Season of summer is from May to Oct. Average temperature in spring season ranges from 23–40^{0}C and average precipitation is about 800 mm per year.

1.7.12 *Vegetation*

Bajaur agency lies on the junction point of Himalayan and Hindukush mountains. Some areas of the agency receive monsoon rainfall and having lush green vegetation such as in Salarzai and Mamund areas. *Pinus roxburghii*, *Olea ferruginea*, *Morus nigra*, *Morus alba*, *Rhododendron arboretum*, *Ficus carica* and *Querqus* spp are the dominant types of vegetation. While on the other side towards Malakand the Barang mountains mostly not receiving precipitation in sufficient amount in summer season due to which most of the vegetation is of scrubby type. *Dodonaea viscosa*, *N. ritchieana, Indigofera hetarantha*, *Myrtis communis*, *Sideroxylon buxifolia*, *Sageratia thea*, *Periploca aphyla, Olea ferrugineae* and *Ailanthus altissima* are the dominant plant taxa in the hills of Barang valley.

Fig. 1.3: Scenic view of study area Bajaur agency

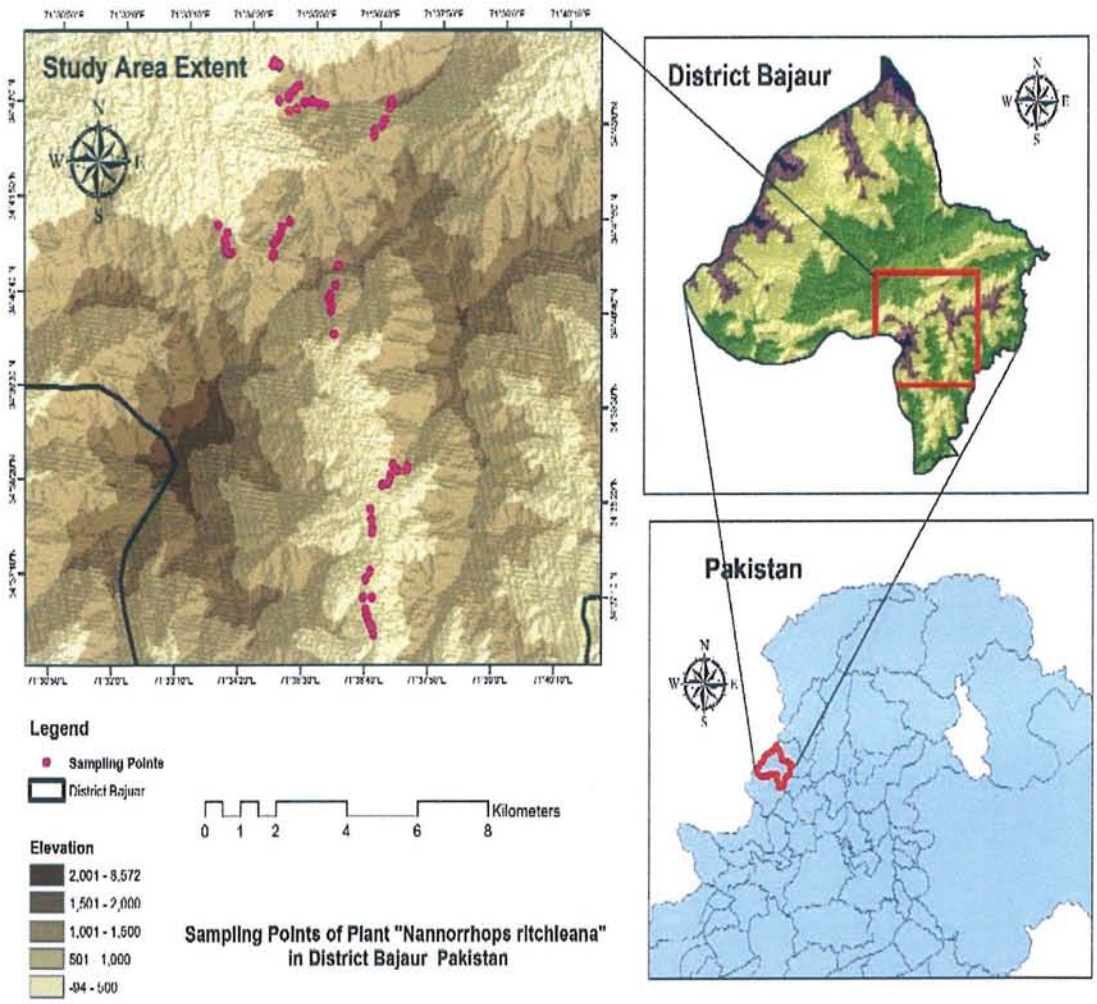

Fig. 1.4: GIS Map of Study area showing distribution of *N. ritchieana*

Chapter 2

MATERIALS AND METHODS

2.1 FIELD SURVEY

Research field work of the current study was conducted in the summer 2017 up to the next summer 2018 in the Agency of Bajaur FATA Pakistan. Before data collection data about the distribution of *N. ritchiana* was gathered from the local peoples of the study area. The informants were interviewed about the distribution of *Nannorrhops*. Whole study area were further divided in to 10 sub areas, 5 of which comes under Barang Tehsil (Takht, Memola, Koisar, Sarlara and Mia khan dara), 3 comes under Khar Tehsil (Sarwakai, Manro and Walai) and 2 comes under Utmankhel Tehsil (Mian Umar Baba and Arang Bado). Each area of the area were designed and considered one transect.

2.1.1 *Materials used during field survey*

During current study various materials were used which were given below

The following materials were used during exploration in study site. These materials were;

(1) Plant presser (2) Newspapers (3) Plant cutter (Knife) (4) Rope (5) Polythene bags (6)Measuring Tap (7) Tags (8) permanent marker (9) Mobile (10) Digger.

2.1.2 *Quadrat method*

Transect approach were used to determine the abundance and association of *N. ritchieana* with associated flora. Transects was designed in those areas where *Nannorrhops* population were present. In each transect number Quadrats were laid down. Quadrat method was used to determine used to determine the Floristic composition and Ecological gradients. Quadrats were laid down in systematic manner using Global Positioning System (GPS). GPS was used record latitude, longitude and altitude of each quadrat. Total of 10 transects were taken in 10 different areas of the study area for sampling vegetation. These 10 transects were further divided into 72 quadrats. Researchers use various type of Quadrats depends upon the vegetation. There are a variety of shapes and size of the Quadrat that depends on the vegetation of an area, for the sampling purpose the square shape Quadrat was used for herbs, shrubs and trees respectively. *N. ritchiana* mostly grows in very tough and rugged rocks where water in scarce amount. The

vegetation of the study area mostly herbaceous and shrubby trees are almost absent. For herb the size of the Quadrat chosen was 1x1 m^2 and for shrub 5x5 m^2. The important parameters recorded were Density, Cover and Frequency of species with grazing pressure etc.

2.1.3 *Measuring Grazing pressure*

Throughout the arid regions of the world grazing pressure is very common. Grazing pressure has a substantial effects on many process and functions of the ecosystem e.g nutrient cycling, soil structure, soil moisture, vegetation composition etc. In other words vegetation and grazing pressure has a very complex relationship. To fulfill the requirement of milk, cattle's raring is an important and common practice in the study area. Every home has a cow, sheep or goat, for their fodder purposes they collect grasses and other plants from wild. Some of them freely release cattle's in forest which is a serious problem for the conservation of indigenous flora. We have recorded grazing pressure in case of shrubs through the number of stumps counted and noted in each Quadrat. In case of herbs we have designated with figures such as 1 for high, 2 for moderate, 3 for low and 4 for zero.

Fig. 2.1: Showing effects of grazing pressure on *Nannorrhops* in its native habitat

2.1.4 *Soil collection*

Soil samples were collected from the rhizosphere of *Nannorrhops* in each Quadrat. Soil samples were putted in polythene bags and marked with respective code of each Quadrat. Soil condition such as sand, gravels, loamy and color e.g black brown etc were noted from soil physical appearance. Soil sample were shade dried, sieved to remove pebbles, remaining of leaves and roots. The sieved samples were packed in zipper bags and transported for further analysis to Ecology and Conservation Lab, Department of Plant Sciences Quaid-i-Azam University Islamabad.

Fig. 2.2: Showing soil collection in study area

2.2 *Lab work*

Soil samples were analyzed for various gradients such as pH, Electrical conductivity (EC), Total Dissolved Solids (TDS) in Ecology and Conservation Lab, Department of Plant Sciences Quaid-i-Azam University Islamabad. Various nutrients and heavy metals were analysis were carried out through Atomic Absorption Spectrometry lab, Department Biochemistry Quaid-i-Azam University Islamabad.

Fig. 2.3: Showing Lab work in the Ecology and Conservation Lab

2.2.1 *pH*

Soil pH were determined through pH meter (model AD 1030 pH/mV). First of all a solution was formed with a 5:1(120ml distilled water and 22 gram soil). The solution was shacked with shaker on 70rpm for 15 minutes after shacking the filtration of solution was carried out via filter paper. The pH of the solution were measured through pH meter.

2.2.2 *Soil Electrical Conductivity (EC)*

Soil electrical conductivity were determined through EC meter (model AD 3000 EC/TDS) . First of all a solution was formed with a 5:1(120ml distilled water and 22 gram soil). The solution was shacked with shaker on 70rpm for 15 minutes after shacking the solution was filtered through filter paper. The EC of the solution were measured through E C meter.

2.2.3 *Total Dissolved Solids (TDS)*

Soil Total Dissolved Solids were determined through TDS meter (model AD 1030 pH/mV) . First of all a solution was formed with a 5:1(120ml distilled water and 22 gram soil). The solution was shacked with shaker on 70 rpm for 15 minutes after shacking the solution was filtered through filter paper. The TDS of the solution were measured through TDS meter.

2.2.4 *Soil samples formation*

Digestion of nutrients and heavy metals were carried out following the sample preparation protocol of (Sharma et al. 2007). A solution was formed of 20% Nitric acid (HNO_3) and 80% Perchloric acid ($HClO_4$) for soil digestion. One gram of soil were added into 10ml of solution from each sample and boiled for 30-40 min oxidize all oxidizable matter easily. After cooling

20ml distilled water were added and the solution were made more concentrated and filtered from filter paper. The filtered materials were transferred into 50ml volumetric flask. Blank solution was prepared without the addition of soil and the other procedure was same.

2.2.5 *Atomic Absorption Spectrometry*

Soil analyses were carried out for nutrients and heavy metals through Atomic Absorption Spectrometer (VARIAN, AA240FS) in the Department of Biochemistry Quaid-i-Azam University Islamabad.

Table 2.1: Shows elements analyzed in Atomic Absorption Spectrometer were carried out

S.NO	Element name	Symbols	Atomic Number	Wave length range	Slit width
1	Chromium	Cr	24	351.9	0.2
2	Cadmium	Cd	48	228.8	0.5
3	Copper	Cu	29	324.8	0.5
4	Nickle	Ni	28	232.0	0.2
5	Plumbum	Pb	82	217.0	1.0
6	Calcium	Ca	20	422.7	0.5
7	Magnesium	Mg	12	285.2	0.5
8	Sodium	Na	11	589.0	0.5
9	Potassium	K	19	766.5	1.0
10	Manganese	Mn	25	279.5	0.2
11	Zinc	Zn	30	213.9	1.0
12	Cobalt	Co	27	240.7	0.2
AA reading X dilution/Wt. of sample		1000mg= 1500IU			

2.3 COLLECTION AND PROCESSING OF PLANT SPECIMENS

During field work plants specimens were collected from each Quadrat. Plants specimens were collected with flowers, leaves and root. Specimens were tagged with specific codes e.g T1Q5P1, T1Q5P2,T3Q3P2 etc. To dry, samples were kept in newspapers. Samples were pressed with plant presser.

Fig. 2.4: Showing collection of the associated flora of *Nannorrhops*

2.3.1 *Identification of Plants samples*

Well dried and fully pressed samples were identified with the help renowned taxonomist Dr. Zahidullah University of Swat. Identified plants specimens were crossed checked with the flora of Pakistan and Standard plant list (Ali and Qaiser 1986). Identified specimens were poisoned with Mercuric chloride (HgCl2).

Fig. 2.5: Showing poisoning of associated plants

2.3.2 *Mounting*

Identified specimens were finally mounted on standard herbarium sheets with length 17.5 and width 11.5 inch. To paste the plant specimens on herbarium sheets German glue were used. After mounting plants herbarium sheets were tagged. Tags were formed on the name of Herbarium of Pakistan Quaid-i-Azam University Islamabad. Tags were labeled Species name, Family, Locality, Alt (Altitude) District, Province, Remarks, Collected by, Number, Date of collection, Determined by (Identified by). After labeling plant pictures were taken with digital camera and submitted to the Herbarium of Pakistan Quaid-i-Azam University Islamabad.

2.4 CLASSIFICATION OF ASSOCIATED FLORA INTO VARIOUS RAUNKIAER LIFE FORM CLASSES

Life form and leaf spectra of associated flora of *N. ritchieana* was determined through Raunkiaer 1934, classification system. All associated plants were categorized in different life form classes such as therophytes, cryptophytes, hemicryptophytes, geophytes, chameophytes and phanerophytes. Detail description of various life form classes were given below.

2.4.1 *Therophytes*

The word Therophytes is the combination of two Greek words Theros means summer and phytes means plants. So the Therophytes are plants which producing seeds and complete their life cycle in very short period of times. In the form of embryo their perennating buds remains dormant in

seeds during unfavorable condition. On the availability of favorable sorts of environment seeds germinate.

2.4.2 *Cryptophytes*

The word Cryptophyte is the combination of two Greek words Kryptos means "hidden" and phytes means plants. Therefore their perennating buds occur in the form of rhizome or bulbs inside the soil (earth). Cryptophytes are also known as Geophytes. Their geophytic character is very important and provide protection and safety in unfavorable conditions such as cool and snow fall. Cryptophytes were further divided into following three sub classes

(i) Geophytes (Aerts and Chapin III)Halophytes (Aerts and Chapin III) Hydrophytes

2.4.3 *Hemicryptophytes*

The word Hemicryptophyte comprises of three Greek words Hemi means half, Kryptos means hidden and phytes means plants. Therefore these are those plants in which the perennating birds are on the surface of earth, hidden by litter or soil. During extreme sorts of environmental condition all vegetative parts of the plants die.

2.4.3 *Chamaephytes*

Chamaephytes is the combination of two Greek words Chamae means "on the ground" and phytes means plants. Thus the chamaephytes are plants with perennating buds up to 25 cm above the ground surface. This class was further classified into four sub classes such as (i) Suffruticose or Semi Shrubby forms Passive or Decumbent forms Active creeping or Stolon forms (iv) Cushion or Polster forms

2.4.4 *Phanerophytes*

The word Phanerophyte is also a combination of two Greek words Phaneros means " Visible" and phytes means plants. Therefore Phanerophytes refers to those plants in which perineal buds are on upper parts more than 25 cm of above the ground surface. Shrubs and trees occur in this class.

2.5 LEAF SPECTRA CLASSES

Leaves of plants also play a key role in the identification of habitat. Mostly Plants of the moist shady places have large while in dry habitat leaf area most of the plants are very small. In desert condition mostly plants leaves are converts to spine like appendages called phylloclade's.

According to (Raunkiaer 1934) leaf can be classified into various leaf classes, some of these are given below

2.5.1 ***Leptophyll***

Leaf area in this class ranges up to $25mm^2$.

2.5.2 Nanophyll

Leaf area in this class ranges from 25 to 25*9 (225 mm2).

2.5.3 ***Microphyll***

leaf area ranges from 225 to 225*9 (2025 mm2)

2.5.4 ***Mesophyll***

leaf surface size ranges from 2025 to 2025*9 (18225 mm2)

2.5.5 ***Macrophyll***

leaf area of this class ranges from18225*9 to (164025 mm2)

2.5.6 ***Megaphyll***

leaf area of this class are above 164025 mm2.

2.6 PHYTOSOCIOLOGICAL ANALYSIS OF THE DATA

To determine phytosociological attributes (Frequency, Relative frequency, Density, Relative Density, Cover and Relative cover) of *N. ritchieana* and its associated plants data that was recorded during field survey were determined. All of these phytosociological attributes were discussed with detail.

2.6.1 ***Density***

Density refers to the number of plants of a specific species in a quadrat out of total quadrats laid down during field survey. In other words it is the representation of "No of individuals of a species for example species A, per total number of Quadrats studied.

It can be denoted Mathematically as;

$$\text{Density (D)} = \frac{\text{No of individuals of a species}}{\text{Total no of Quadrats}}$$

2.6.2 ***Relative Density***

Relative density is the mark representation of mathematical value that can be expressed in % and can be find out as

$$\text{Relative density} = \frac{\text{Density of a species}}{\text{Density of all species}} \times 100$$

2.6.3 ***Frequency***

Frequency is the existence of a in a specific quadrat. It can be determined through the following formula

$$\text{Frequency} = \frac{\text{No of Quadrats in which a species occur}}{\text{Total no of Quadrats}}$$

2.6.4 ***Relative frequency***

According to Raunkiaer (1934) relative frequency is the No of occurrence of a species divided by no of occurrence of all species multiplied by 100.

$$\textbf{Relative frequency} = \frac{\textbf{Relative frequency of a species}}{\textbf{Total frequencies of All species}} \textbf{ X 100}$$

2.6.5 ***Cover***

Cover is a very significant parameter regularly used for ecological sampling. It can be defined as, area covered by a species in a Quadrat divided by total area of that Quadrat. This type of approach used in case of shrubs and herbs. For measuring cover of trees another method is used but in current research work we have not a single tree that's why here methodology for measuring cover of herb and shrub have mentioned.

$$\textbf{Cover} = \frac{\text{Total area occupied by a Species}}{\text{No of individuals of that particular Species}}$$

2.6.6 ***Relative Cover***

Relative cover of a species can be determined as when total cover of a single species divided by total cover of all species and then multiplied with one hundred.

$$\text{Relative Cover} = \frac{\text{Total cover of all individual of a single Species}}{\text{Total cover of all Species}} \times 100$$

2.6.7 *Important Value Index (IVI)*

Important Value Index is of prime importance in the determination of dominant species of a community of plants. It can be determined through the methods of Curtis and Cottom (1956). According to this method IVI of a species can be determined as

$$\textbf{Important Value Index (IVI)} = \frac{\textbf{RF+RD+RC}}{\textbf{3}}$$

2.7 DATA MATRIX FOR VARIOUS SOFTWARE'S

For statistical analysis Both sorts of data sets like vegetation and environmental data were properly put onto MS-excel sheets according to the requirements of PC-ORD Version 5. The data that was collected from 134 Quadrats have revealed a total of 195 different plant species belongs to different habits. The plant species data and environmental data such as pH, Electrical conductivity, Texture (Sand, Silt and Clay), dead organic matter, Nitrogen contents, Phosphorus, Potassium, Aspect, Grazing pressure were analyzed via a software PC-ORD version no. 5 (McCune and Mefford 1999). Both types of analyses like Cluster Analysis and Two Way Cluster Analysis assisted in the identification of habitat and plant communities by using Sorensen measures, based on binary or 0,1 data (Greig-Smith 1983). CCA software of version 4.5 was applied on data that have pinpointed the relation among the different plant species in relation to environmental data. Subsequently the Indicator Species Analysis was used for the linkage of abundance and floristic composition data with ecological gradients mentioned above. The indicator values of each plant species in every group was achieved and tested for statistical significance by using the MCT or Monte Carlo Test. ISA have evaluated the response of each of the plant species to ecological gradients from the environmental matrix. A threshold indicator value of 30 % with 95 % significance (P* value ≤ 0.05) was selected for the proper identification

of indicator species (Dufrêne and Legendre 1997), later on the properly identified indicator species were used for naming plant communities.

2.8 MULTIVARIATE STATISTICAL ANALYSIS

Multivariate statistical analysis of the data was carried out through the application of classification and ordination techniques. For this purpose data was arranged in columns and rows. Plants names and Quadrats were putted in columns and rows respectively. For the presence and absence of species 1,0, data were formed. The PCORD- V.5 were used for cluster analysis and two way cluster analysis. Cluster and two way cluster analysis were carried out to determine relationship among plants communities and plant communities with environmental data. Traditional old phytosociological methodologies, used previous times for classification were somewhat of subjective type. To analyze a large scale survey these techniques were difficult in use because to analyze samples in number of hundreds was length for classification. In current era with introduction of various numerical classification techniques for categorization, in approach were somewhat subjective. Furthermore the modern and quick computer and laptop systems have increased it applications and popularity.

2.8 EVALUATION OF CONSERVATION STATUS

To declare conservation status of *Nannorrhops* extent of occurrence (E00) were measured through google earth path application. Longitude, Latitude and Altitude were through GPS application for each quadrat. With the help of coordinates main location of each quadrat and transect were pin pointed on google earth. Length and width of each transect were measured through google earth ruler while total area of each transect were measured via google earth path. After measuring EOO and AOO throughout the study area IUCN red list (V.17) Categories and criteria were applied. The concern plant species were categorized into its respective category,

RESULTS

It is a hard palm which can survive in variety of climates and can tolerate -20 to 50^{0}C temperature. It prefer mostly the South facing slopes where the rays of sun directly penetrates. Grazing pressure, over exploitation and weathering of rocks for various purposes are some common threats to *N. ritchieana* habitat was under various pressure such as grazing pressure, low precipitation in summer season and anthropogenic pressure. The associated plants species were herbs and shrubs trees were absent. The species prefer mostly the calcareous rocks habitat.

3.1 TAXANOMIC GROUPS OF *NANNORRHOPS RITCHIANA* ASOCIATED FLORA

N. ritchieana is a gregarious palm species grows in association with other plants in its natural habitat. Our result show that it is associated with 69 plant species in 10 sites of the study area. The associated flora comprises of 27 families (Table 3.1) Poaceae was the dominant family with 15 species followed by Asteraceae and Lamiaceae with 8 species each (Fig 3.1). Other families such as Primulaceae with 3 species and Amaranthaceae, Boraginaceae, Caryophyllaceae, Cyperaceae, polygonaceae, Pteridaceae, Solanaceae are the families comprises of 2 species each while the Apocynaaceae, Arecaceae, Asparagaceae, Aspleniaceae, Celastraceae, Convulvulaceae, Euphorbiaceae, Nyctaginaceae, Oxilidaceaae, Plumbaginaceae, Polygonaceae, Rhamnaceae, Sapindaceae, Scrophulariaceae, Verbenaceae are the families with 1 species each.

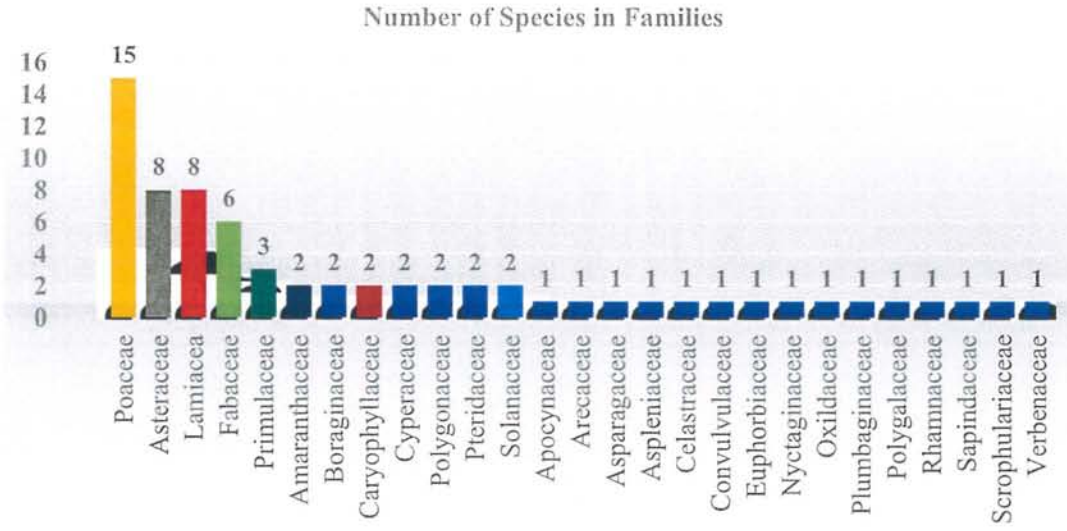

Fig. 3.1 No of species of associated plants in various families

3.2 CLASSIFICATION OF ASSOCIATED FLOR IN VARIOUS RAUNKAIER LIFE FORM CLASSESS

Acoording to Raunkaier life form classes the species were divided into different classes (Table 3.1) Therophytes was the dominant class with 32 (Table 3.1) species followed by Hemicryptophytes with 18 species, Phanerophytes 6 species, Chaemyphytes 6 species, Griptophytes 4 species, Nanophanerophytes 3 species and Geophytes class with 1 species (Fig 3.2).

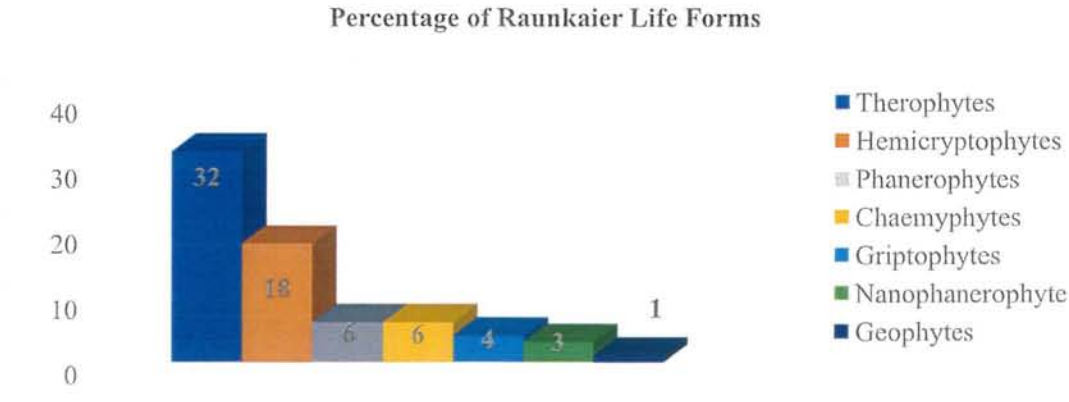

Fig. 3.2 No of species of associated flora in Life form classes

3.3 BIOLOGICAL LEAF SPECTRA CLASSES OF ASSOCIATED FLORA

According Raunkaier leaf spectra classes associted flora of *Nannorrhops* were divded into various different classes (Table 3.1) Leptophyll was the dominat leaf spectra class with 28 species followed by Micophyll with 16 species, Mesophyll 12 species, Nanophyll 12 species, Aphyll and Macrophyll with one species each (Fig 3.3).

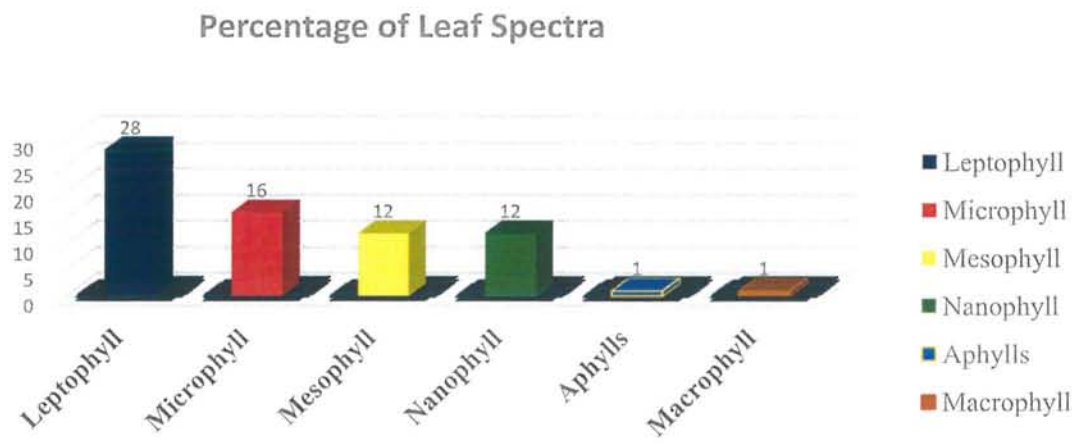

Fig. 3.3 Showing leaf spectra classes of associated flora

3.4 Classification of Associated flora on the basis of Habit

On the basis of habit the flora was classified into 2 groups herbs and shrubs while the trees were absent. The contribution of herbs were 89% and shrubs were 11% (Fig 3.4). *Dodonaea viscosa*, *Periploca aphyla*, *Gymnosporia royleana*, *Indigofera hetarantha* etc were the shrub species.

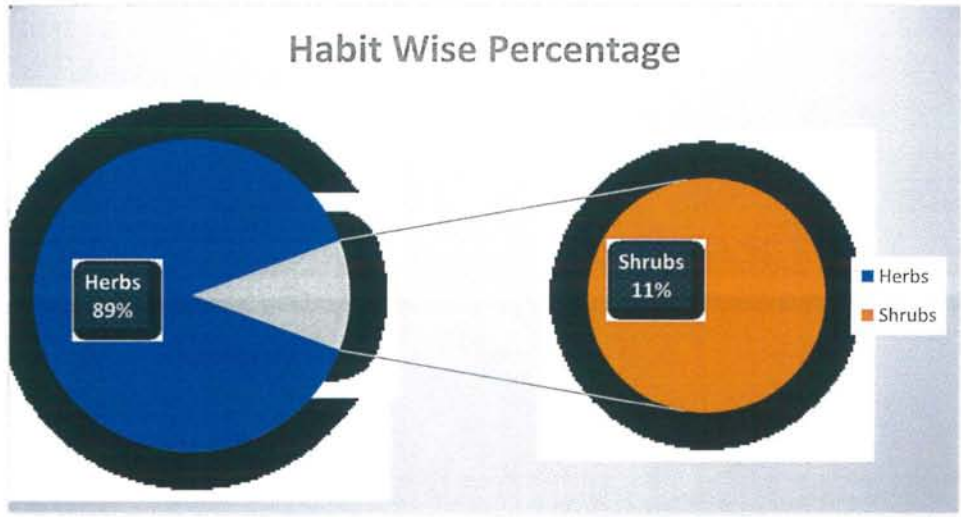

Fig. 3.4 Habit wise percentage of associated flora

Table 3.1: showing Plants name with families, life form and leaf spectra classes

S.No	Plant names	Families	Families %age	Habit	Life form Classes	Leaf Spectra Classes
1	*Aerva javanica* (Burm.f.) Juss. ex Schult	Amaranthaceae	1%	Herb	Chamaephytes	Mesophyll
2	*Chenopodium album* L.			Herb	Therophytes	Mesophyll
3	*Periploca aphylla* Decne.	Apocynaceae	1%	Shrub	Phaneriophyte	Aphyll
4	*Nannorrhops ritchieana* (Griff.) Aitch	Arecaceae	1%	Shrub	Phaneriophyte	Macrophyll
5	*Asparagus racemosus* Willd.	Asparagaceae	1%	Herb	Chamaephytes	Leptophyll
6	*Ceterach officinarum Willd*	Aspleniaceae	1%	Herb	Griptophytes	Nanophyll
7	*Carthamus oxyacantha* M.Bieb	Asteraceae	11%	Herb	Therophytes	Nanophyll
8	*Erigeron bonariensis* L.			Herb	Hemicryptophytes	Leptophyll
9	*Erigeron canadensis* L.			Herb	Hemicryptophytes	Leptophyll
10	*Filago hurdwarica* (Wall. ex DC.) Wagenitz			Herb	Therophytes	Microphyll
11	*Sonchus oleraceus* (L.) L.			Herb	Therophytes	Mesophyll
12	*Symphyotrichum grandiflorum* (L.) G.L.Nesom			Herb	Chaemyphytes	Leptophyll
13	*Taraxacum officinale* (L.) Weber ex F.H.Wigg			Herb	Therophytes	Mesophyll

14	*Xanthium strumarium* L.			Herb	Therophytes	Mesophyll
15	*Chrozophora tinctoria* (L.) A.Juss.	Boraginaceae	3%	Herb	Hemicryptophytes	Mesophyll
16	*Heliotropium marifolium* J.Koenig ex Retz			Herb	Geophytes	Leptophyll
17	*Spergularia diandra* (Guss.) Heldr.	Caryophyllaceae	3%	Herb	Therophytes	Nanophyll
18	*Stellaria media* (L.) Vill.			Herb	Therophytes	Leptophyll
19	*Gymnosporia royleana* Wall. ex M.A.Lawson	Celastraceae	1%	Shrub	Nanophanerophyte	Microphyll
20	*Convolvulus arvensis* L.	Convulvulaceae	1%	Herb	Therophytes	Mesophyll
21	*Cyperus rotundus* L.	Cyperaceae	3%	Herb	Griptophytes	Leptophyll
22	*Eriophorum comosum* (Wall.) Nees			Herb	Hemicryptophytes	Leptophyll
23	*Euphorbia hispida* Boiss.	Euphorbiaceae	1%	Herb	Therophytes	Leptophyll
24	*Argyrolobium roseum* (Cambess.) Jaub. & Spach	Fabaceae	9%	Herb	Hemicryptophytes	Nanophyll
25	*Crotalaria medicaginea* Lam.			Herb	Therophytes	Nanophyll
26	*Lespedeza juncea* (L.f.) Pers			Herb	Therophytes	Microphyll
27	*Medicago polymorpha* L			Herb	Therophytes	Nanophyll
28	*Vicia sativa* L.			Herb	Therophytes	Nanophyll
29	*Indigofera heterantha* Brandis	Lamiaceae	11%	Shrub	Phanerophytes	Leptophyll
30	*Ajuga parviflora* Benth			Herb	Therophytes	Microphyll

31	*Micromeria biflora* (Buc h.-Ham. ex D.Don) Benth			Herb	Therophytes	Microphyll
32	*Phlomidoschema parviflorum* (Benth.) Vved			Herb	Chaemyphytes	Microphyll
33	*Salvia moorcroftiana* Wall. ex Benth.			Herb	Chaemyphytes	Mesophyll
34	*Teucrium stocksianum* Boiss			Herb	Hemicryptophytes	Microphyll
35	*Rydingia limbata* (Benth.) Scheen & V.A.Albert			Shrub	Phanerophyte	Microphyll
36	*Scutellaria scandens* D.D on			Herb	Therophytes	Leptophyll
37	*Rydingia persica* (Burm.f.) Scheen & V.A.Albert			Shrub	Phanerophytes	Microphyll
38	*Boerhavia procumbens* B anks ex Roxb.	Nyctaginaceae	1%	Herb	Therophytes	Nanophyll
39	*Oxalis corniculata* L	Oxildaceae	1%	Herb	Therophytes	Microphyll
40	*Limonium cabulicum* (Boiss.) Kuntze	Plumbaginacea e	1%	Herb	Nanophanerophyte	Mesophyll
41	*Acrachne racemosa* (B.Heyne ex Roth) Ohwi			Herb	Hemicryptophytes	Leptophyll
42	*Aristida adscensionis* L.			Herb	Hemicryptophytes	Leptophyll
43	*Brachiaria ramosa* (L.) Stapf			Herb	Therophytes	Leptophyll
44	*Bromus japonicus* Thunb	Poaceae	21%	Herb	Therophytes	Leptophyll

45	*Chrysopogon aucheri* (Boiss.) Stapf.			Herb	Hemicryptophytes	Leptophyll
46	*Cymbopogon commutatus* (Steud.) Stapf.			Herb	Hemicryptophytes	Leptophyll
47	*Cymbopogon martini* (Roxb.) W.Watson.			Herb	Hemicryptophytes	Leptophyll
48	*Cymbopogon jwarancusa* (Jones) Schult.			Herb	Hemicryptophytes	Leptophyll
49	*Cynodon dactylon* (L.) Pers.			Herb	Hemicryptophytes	Leptophyll
50	*Desmostachya bipinnata* (L.) Stapf			Herb	Hemicryptophytes	Leptophyll
51	*Dichanthium annulatum* (Forssk.) Stapf			Herb	Hemicryptophytes	Leptophyll
52	*Echinochloa colona* (L.) Link			Herb	Hemicryptophytes	Leptophyll
53	*Echinops echinatus* Roxb.			Herb	Therophytes	Microphyll
54	*Eragrostis cilianensis* (All.) Janch			Herb	Hemicryptophytes	Leptophyll
55	*Saccharum spontaneum* L			Herb	Hemicryptophytes	Leptophyll
56	*Polygala supina* subsp. *rhodopea* (Velen.) McNeill	Polygalaceae	1%	Herb	Therophytes	Nanophyll
57	*Polygonum paronychioides* C.A. Mey			Herb	Therophytes	Nanophyll
58	*Rumex hastatus* D. Don	Polygonaceae	3%	Herb	Chaemyphytes	Nanophyll
59	*Anagallis arvensis* L	Primulaceae	4%	Herb	Therophytes	Leptophyll

60	*Androsace rotundifolia* Hardw			Herb	Therophytes	Microphyll
61	*Erodium cicutarium* (L.) L'Hér.			Herb	Therophytes	Mesophyll
62	*Adiantum caudatum* L.			Herb	Griptophytes	Leptophyl
63	Cheilanthes acrostica (Balb.) Tod	Pteridaceae	3%	Herb	Griptophytes	Leptophyl
64	*Ziziphus oxyphylla* Edgew	Rhamnaceae	1%	Shrub	Phanerophytes	Microphyll
65	*Dodonaea viscosa* (L.) Jacq.	Sapindaceae	1%	Shrub	Nanophanerophyte	Microphyll
66	*Verbascum thapsus* L.	Scrophulariaceae	1%	Herb	Therophytes	Mesophyll
67	*Solanum surattense* Burm. f.			Herb	Therophytes	Mesophyll
68	*Physalis peruviana* L.	Solanaceae	3%	Herb	Therophytes	Microphyll
69	*Verbena officinalis* L.	Verbenaceae	1%	Herb	Therophytes	Microphyll
70	*Tribulus terrestris* L.	Zygophyllaceae	1%	Herb	Therophytes	Nanophyl

Table 3.2: showing longitude, latitude and altitude of each quadrat in study area

S.No	Quadrat No	Longitude	Latitude	Altitude (m)
1	T1Q1	34.635654	71.611642	833.33
2	T1Q2	34.633018	71.612582	830
3	T1Q3	34.631712	71.612752	825
4	T1Q4	34.629919	71.612668	822
5	T1Q5	34.622765	71.612423	772
6	T1Q6	34.621116	71.611108	780
7	T1Q7	34.617288	71.610576	752
8	T1Q8	34.617382	71.613243	764
9	T2 Q1	34.671375	71.599388	952.41
10	T2Q2	34.676157	71.598327	1003

11	T2Q3	34.677316	71.598337	1080
12	T2Q4	34.678389	71.597883	1155
13	T2Q5	34.679271	71.596897	1258
14	T2Q6	34.580134	71.592979	1357
15	T2Q7	34.689623	71.587419	1437
16	T3Q1	34.726051	71.579785	880
17	T3Q2	34.72597409	71.58036521	886
18	T3Q3	34.72628455	71.58036521	911.82
19	T3Q4	34.726053	71.580367	915
20	T3Q5	34.726154	71.580466	913
21	T3Q6	34.726155	71.578491	921
22	T4Q1	34.640626	71.615467	832.55
23	T4Q2	34.641276	71.617702	910
24	T4Q3	34.642524	71.61795	939
25	T4Q4	34.642844	71.618009	958.49
26	T4Q5	34.642701	71.618011	1003
27	T4Q6	34.643799	71.619985	1030
28	T4Q7	34.644053	71.622885	1039
29	T4Q8	34.644767	71.623311	1054
30	T5Q1	34.712506	71.610072	1061
31	T5Q2	34.713561	71.610113	1109
32	T5Q3	34.714735	71.612551	1160.18
33	T5Q4	34.715817	71.613242	1290
34	T5Q5	34.718365	71.614742	1377
35	T5Q6	34.718917	71.615324	1434
36	T5Q7	34.719774	71.615238	1541
37	T6Q1	34.718886	71.580724	943.56
38	T6Q2	34.71954813	71.58347694	955
39	T6Q3	34.72003179	71.58375228	1008.1
40	T6Q4	34.720051	71.584081	1051.43
41	T6Q5	34.721047	71.5855136	1089
42	T6Q6	34.72215609	71.58664221	1102
43	T7Q1	34.687165	71.567292	991.3
44	T7Q2	34.687183	71.566121	1039
45	T7Q3	34.687566	71.565736	1073
46	T7Q4	34.687865	71.565495	1117.88
47	T7Q5	34.688228	71.564747	1149
48	T7Q6	34.688316	71.564395	1168
49	T7Q7	34.688214	71.563238	1200
50	T7Q8	34.687529	71.563009	1247

51	T8Q1	34.687165	71.566121	1008
52	T8Q2	34.688822	71.576948	1051
53	T8Q3	34.689488	71.58022	1118
54	T8Q4	34.690248	71.581022	1164
55	T8Q5	34.690566	71.581576	1208
56	T8Q6	34.691584	71.582084	1268.71
57	T8Q7	34.691978	71.582524	1304
58	T8Q8	34.692277	71.583521	1342.84
59	T9Q1	34.7168847	71.5837855	990.23
60	T9Q2	34.717365	71.58624489	1077
61	T9Q3	34.718728	71.588328	1115
62	T9Q4	34.718944	71.5896578	1157
63	T9Q5	34.719058	71.5908471	1189
64	T9Q6	34.71849	71.592967	1220
65	T9Q7	34.718328	71.594623	1306
66	T10Q1	34.609774	71.613965	741.85
67	T10Q2	34.610759	71.613595	791
68	T10Q3	34.611634	71.613225	827
69	T10Q4	34.612456	71.612504	867
70	T10Q5	34.613345	71.612047	861
71	T10Q6	34.613874	71.611661	826
72	T10Q7	34.614945	71.611409	772

3.5 Species Area Curves

Species area curves through PCORD version were calculated to justify the adequacy of the sample size in the data of community. Through Sorenson distance and importance value the species area curve was constructed following the methodology of McCune and Mefford (1999). Species area curves were used to assess or determine whether the sample size was enough to get sufficient appearance of a species in relation to total area of the study. Through species area curve we can determine number of species in each transect. Species Area Curves also play an important role in the understanding of biodiversity as well as in its conservation. (He & Legendre, 1996, Legendre *et al.*, 2005). In current study we have formed the species area curve of 10 transects (Fig. 3.5) which show that the new species not appears further in the study area because *N. ritchieana* occur in dry habitats where the number of associated species are very low

and mostly grasses. This revealed that the current study for the associated flora of *Nannorrhops* is sufficient in Bajaur Agency.

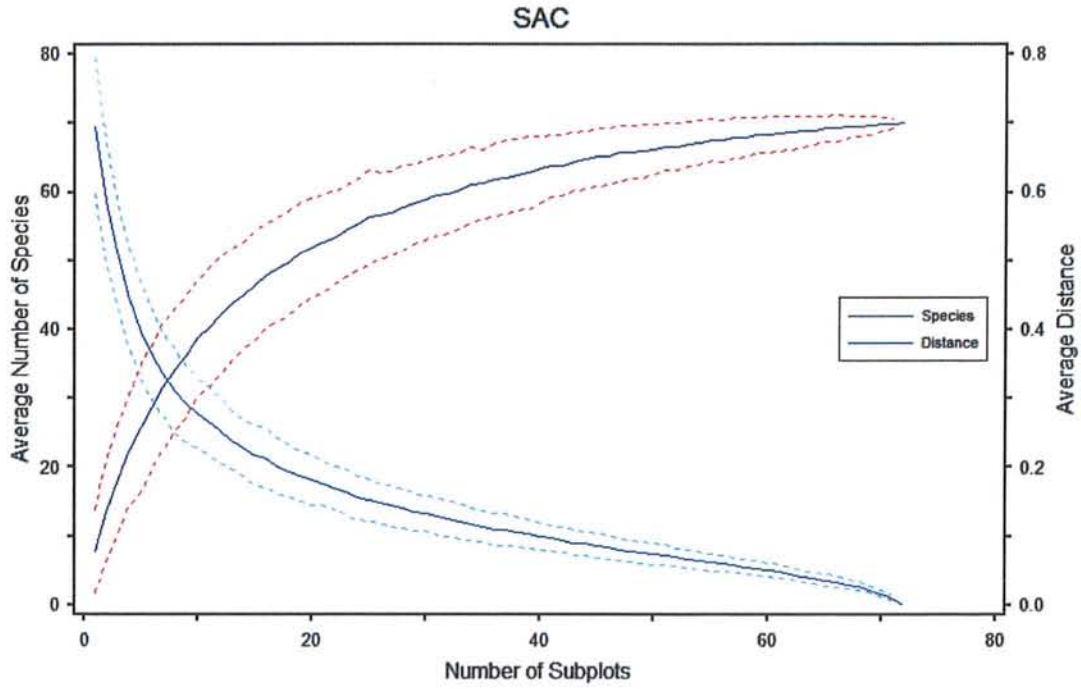

Fig. 3.5 Species Area Curves show the adequacy of the samples in study area

It is obvious that the *N. ritchieana* is a gregarious (sociable) species which cannot live alone and form associations or communities. The total plants were divided into four associations. These associations were formed through PCORD version 5 through cluster analysis (3.6). Name were given to each association on the basis of indicator species and environmental drivers. Indicator species were find out for each association CANOCO software. Environmental variables play an important role in association as well as in the distribution species. Detail description and its multivariate statistics were given for each association.

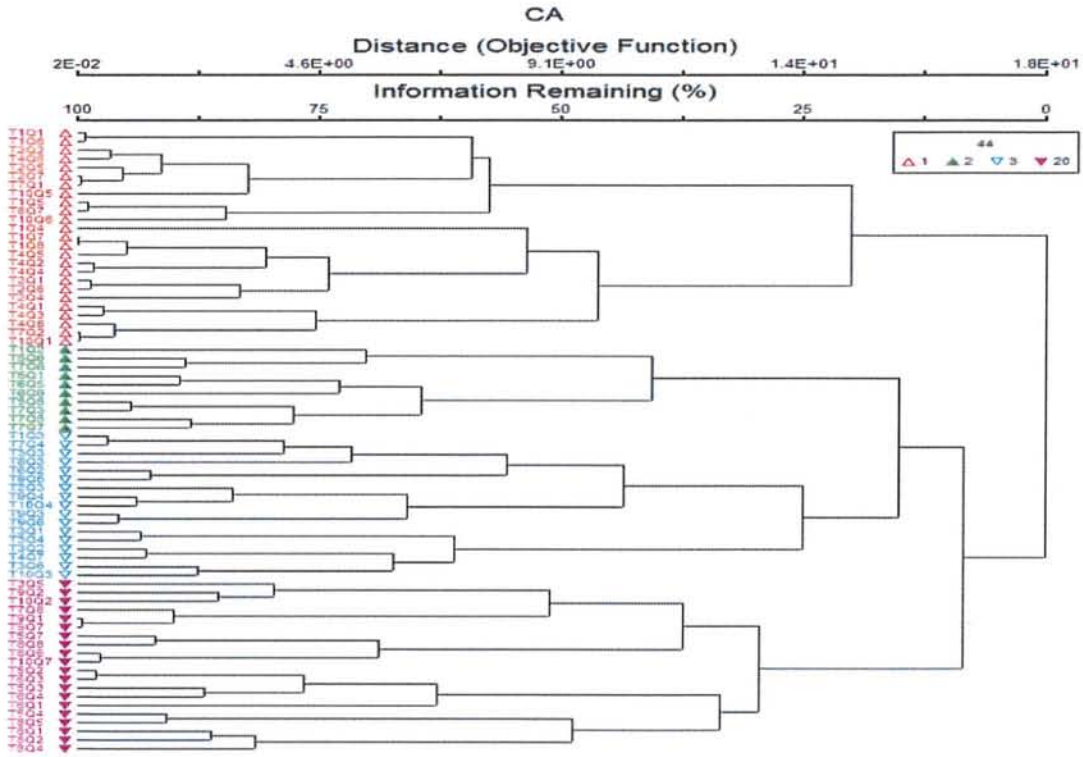

Fig. 3.6 Cluster dendrogram showing associations formed by *N. ritchiana* and its associated flora

3.6 Determination of indicator species

3.6.1 Association 01; Aerva javanica- Spergularia diandara -Dodoneae viscosa

Cluster (Fig 3.6) and two way Cluster dendrogram (3.7) show that 01 association comprises of 25 Quadrats based on Sorenson similarity index i.e T1Q1, T1Q6, T2Q2, T4Q6, T2Q5, T2Q7,T7Q1, T10Q5, T1Q5, T8Q7, T10Q6, T1Q4, T1Q7, T1Q8, T4Q5, T4Q2, T4Q4, T2Q1, T2Q6, T2Q4, T4Q1, T4Q3, T4Q8,T7Q2, T10Q1. Name to 01 association were given on the basis of Indicator species. Indicators were determined on the basis of P* and IV value. Those species which have P* value less or equal to and IV value greater than 20 were considered indicators species (P* Value $\leq$ 0.05, and IV $\geq$ 20). Generally three species one tree, one shrub and one herb were selected as indicator species. In current study the tree species were absent so one indicator from shrub and two indicators from herbs were selected in each community.

Characteristic or indicator species of this association are *Aerva javanica, Spergularia diandara* and *Dodoneae viscosa* (Table 3.3). These indicators mostly occur in dry zones of the area.

Table 3.3 indicator species and its variables of 1st association

Total numbers of Quadrats= 25				
S.No	**Indicator species**	Variables	IV	**P* Value**
1	*Aerva javanica*	Gp	25.0	0.0068
2	*Spergularia diandara*	Na	21.4	0.0294
3	*Dodoneae viscosa*	Gp	42	0.0004

Dominant herbs

Cymbopogon commutatus- Bromus japonicus- Phlomidoschema parviflorum

Dominant Shrubs

Gymnosporia royleana -Dodonaea viscosa- Indigofera hetarantha

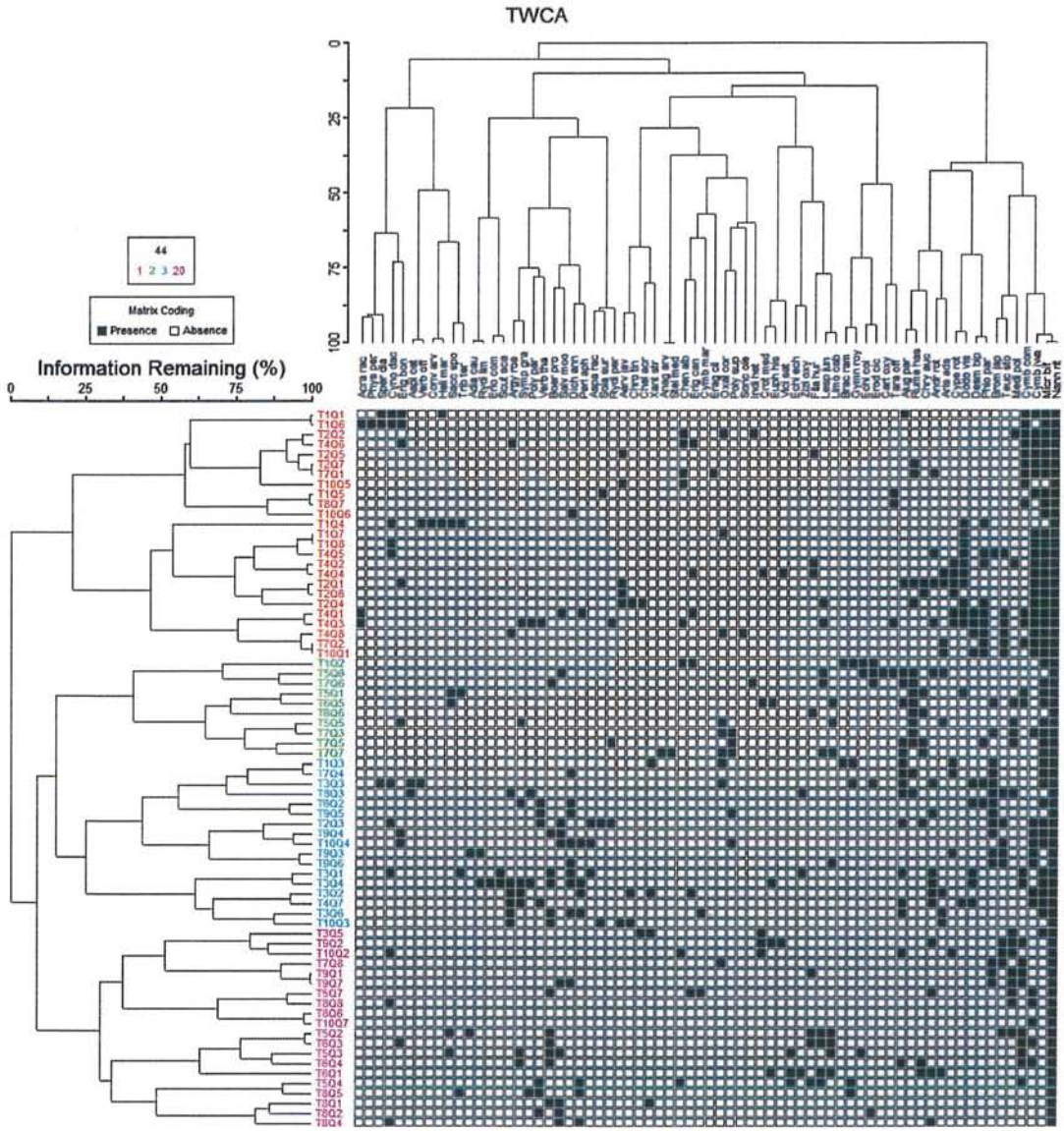

Fig. 3.7 TWCA dendrogram showing 4 associations formed by *N. ritchiana* and its associated flora

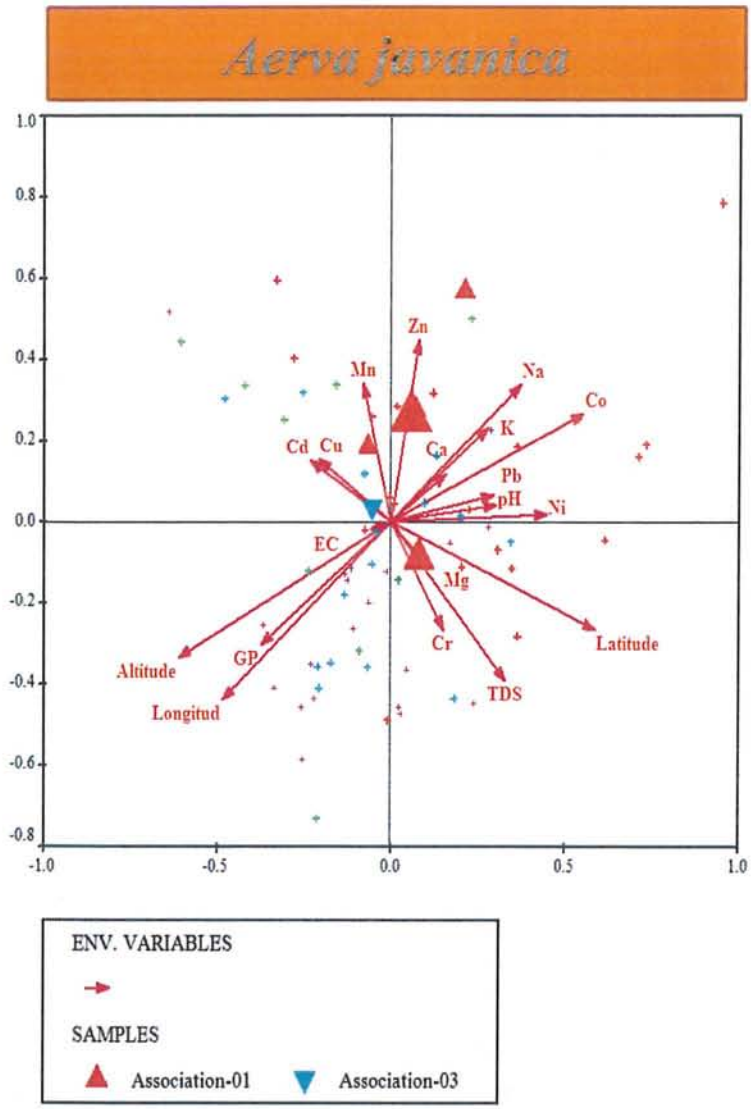

Fig 3.8 CCA (attribute plot) of *Aerva javanica* 1st indicator species of 01 Association

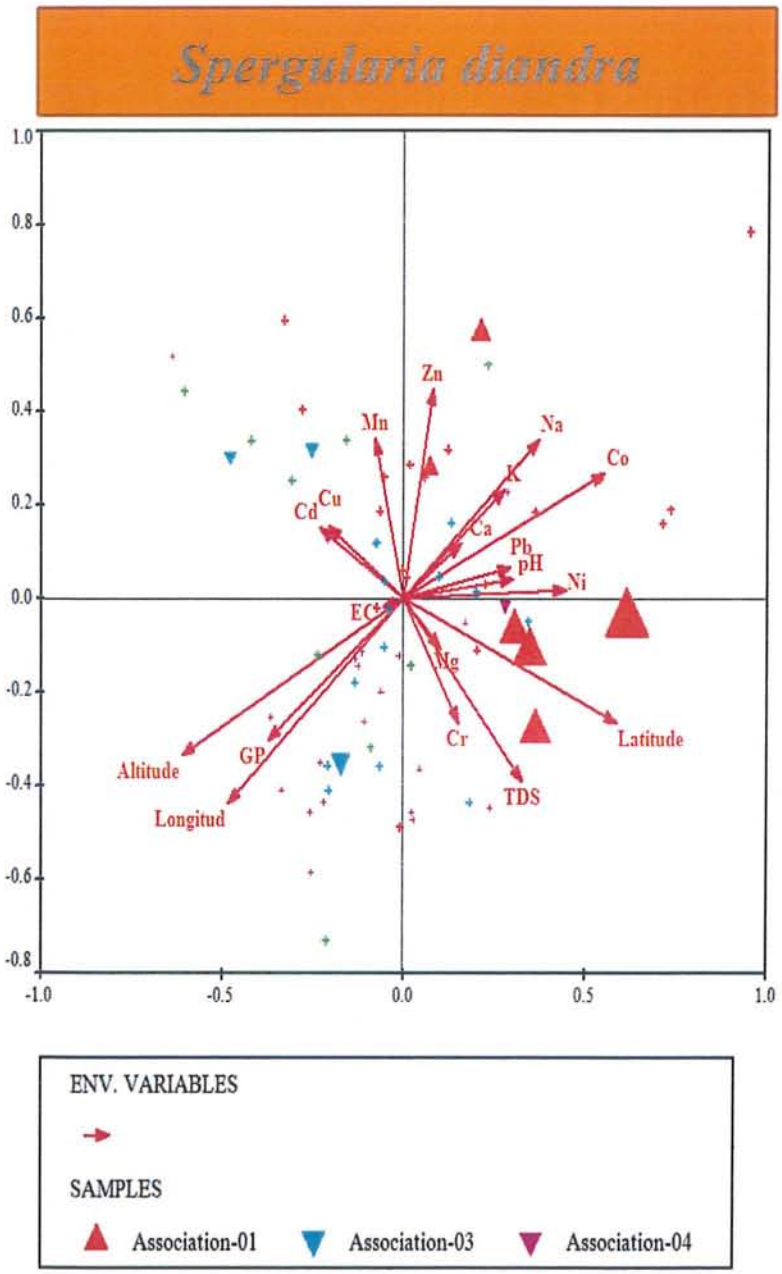

Fig 3.10 CCA (attribute plot) of *Spergularia diandra* 2nd indicator species of 01 Association

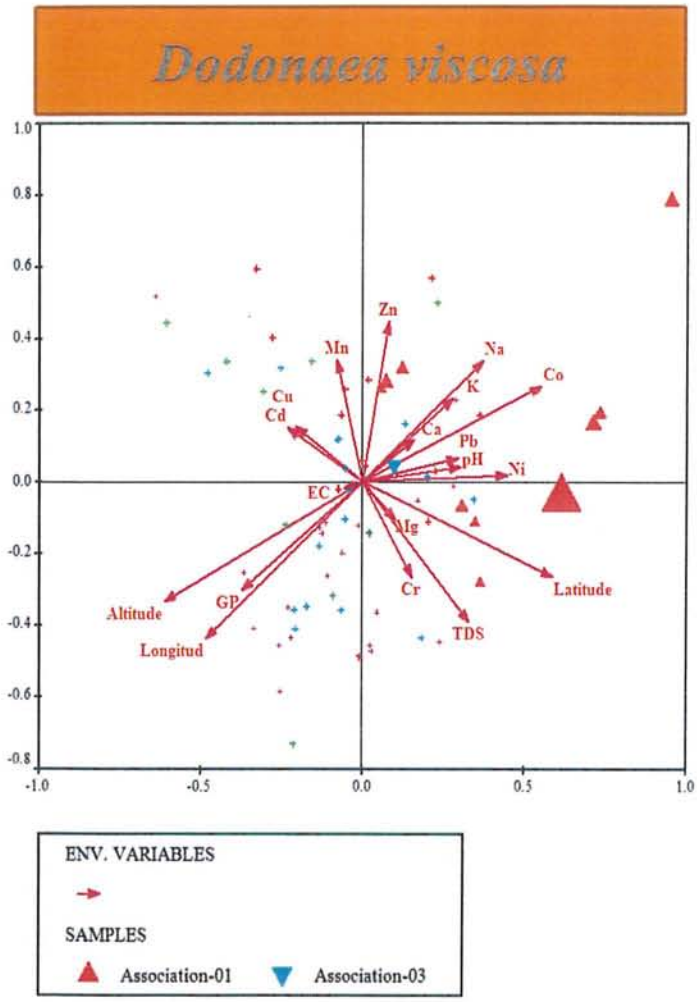

Fig 3.11 CCA (attribute plot) of *Dodonaea viscosa* 3rd indicator species of 01 association

3.6.2 02 Association *Erodium cicotarium-Tribulus terrestris-Gymnosporea royleana*

The second association consist on the cluster of eleven quadrats i.e T1Q2, T5Q6, T7Q6,T5Q1, T6Q5, T6Q6, T5Q5, T7Q3, T7Q5, T7Q7. Indicator species of this association are *Erodium cicotarium*, *Tribulus terrestris* and *Gymnosporea royleana* (Table 3.4). These species are the indicators of Magnesium. *Medicago polymorpha, Cynodon dactylon, Lespedez juncea* are the dominant herbs of the second association. *Gymnosporea royleana, Indigofera hetarantha, Rydingia persica* are the dominant shrubs of the 02 association.

Table 3.4 indicator species and its variables of 2nd association

Total numbers of Quadrats= 10				
S.No	**Indicator species**	**Variables**	**IV**	**P* Value**
1	**Erodium cicotarium**	Mg	26.3	0.0928
2	*Tribulus terrestris*	Mg	40.1	0.0804
3	*Gymnosporia royleana*	Mg	40.9	0.0976

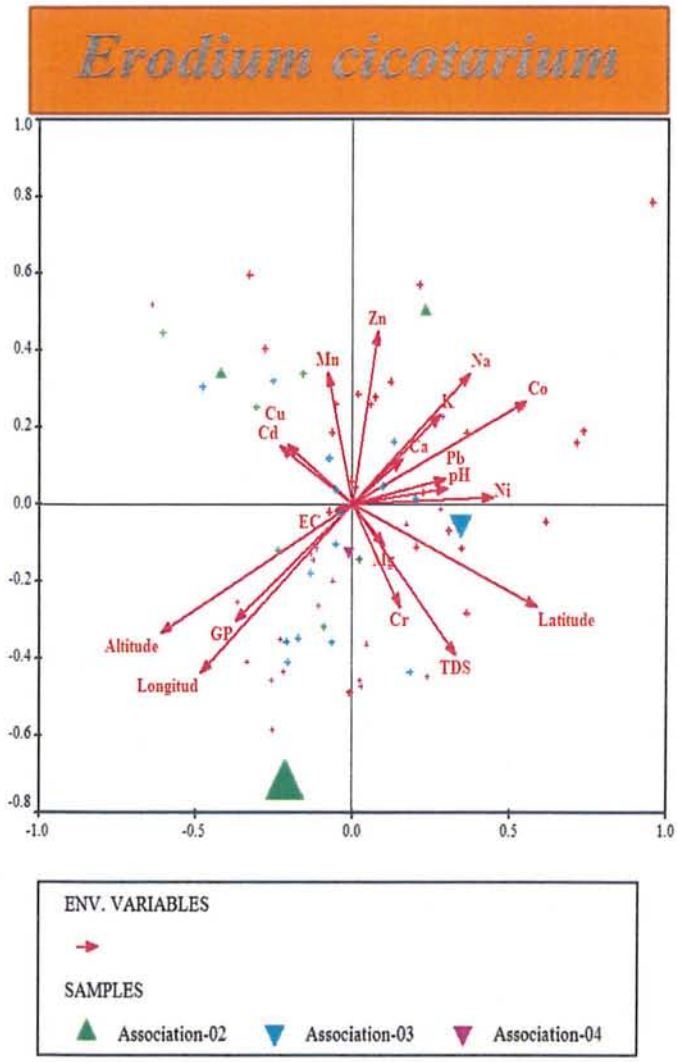

Fig 3.12 CCA (attribute plot) of *Erodium cicotarium* 1st indicator species of 02 association

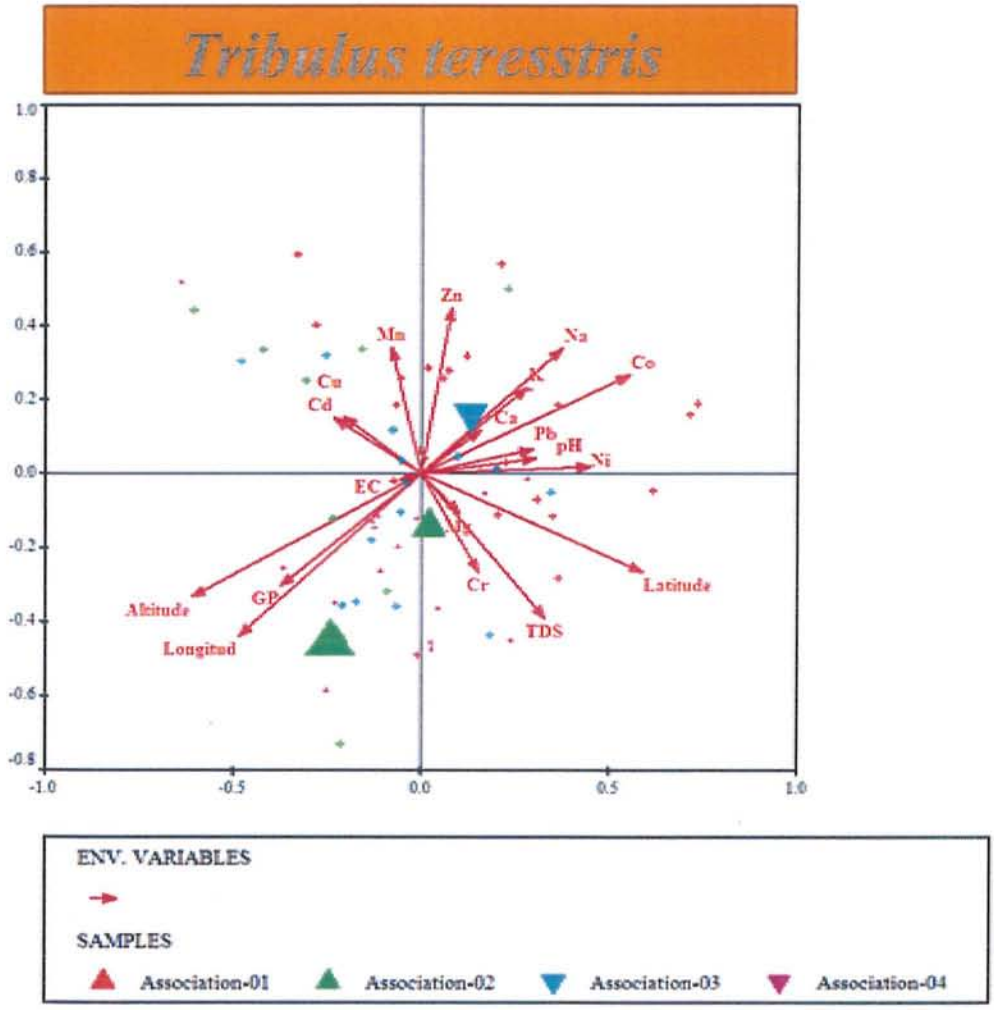

Fig 3.13 CCA (attribute plot) of *Tribulus terrestris* 2nd indicator species of 02 association

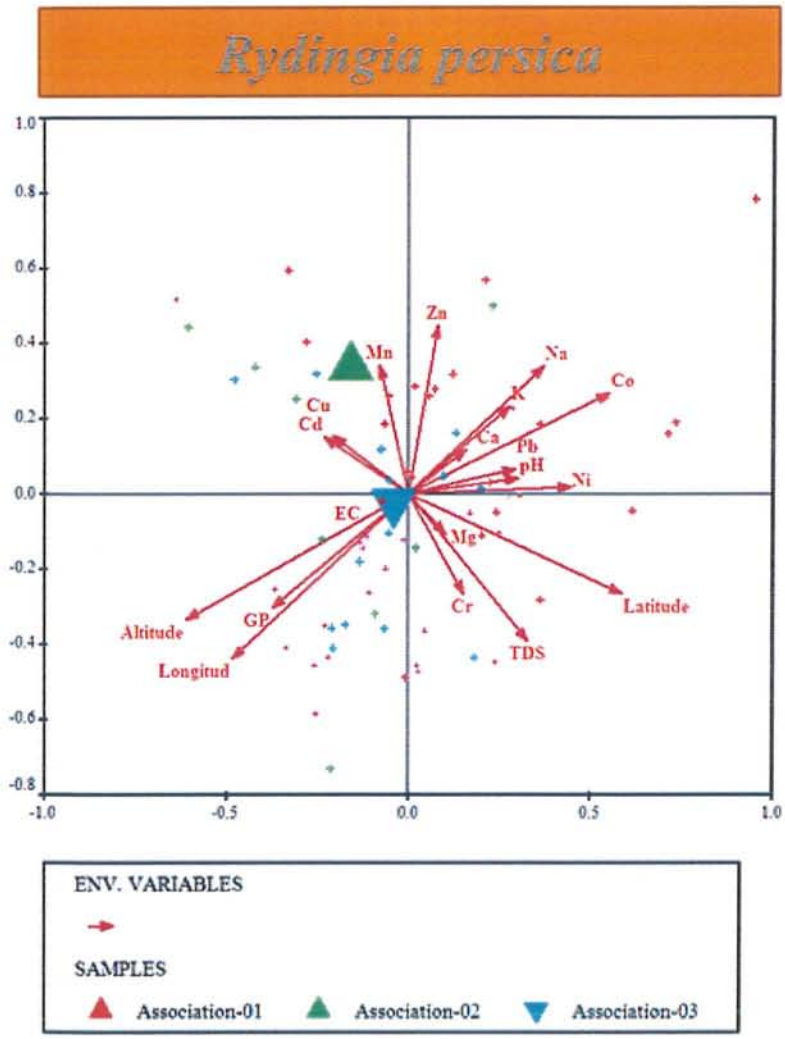

Fig 3.14 CCA (attribute plot) of *Tribulus terrestris* 3rd indicator species of 02 association

3.6.3 03 Association *Acrachane racemosa -Cyperus rotundus-Gymnosporea royleana*

This association comprises on the cluster of 17 Quadrats. *Acrachane racemosa, Cyperus rotundus and Gymnosporea royleana* are the indicators of the 03 association (Table 3.5). The *Acrachane racemose* and *cyperus rotundus* are the indicators of high grazing pressure while the *Gymnosporea royleana* were the indictor of high magnesium concentration. These species are the indicator of the association which is formed by T1Q3, T7Q4, T3Q3, T6Q3, T6Q2, T9Q5, T2Q3, T9Q4, T10Q4, T9Q3, T9Q6, T3Q1, T3Q4, T3Q2, T4Q7, T3Q6 and T10Q3 Quadrat. The Dominant herbs comprises of *Teucrium stockcianum, Dichanthium annulatum and Androsac rotundifolia* while the dominant shrubs were *Gymnosporia royleana, Periploca aphyla and Dodonaea viscosa.*

Table 3.5 indicator species and its variables of 3rd association

Total numbers of Quadrats= 17				
S.No	**Indicator species**	**Variables**	**IV**	**P* Value**
1	**Cyperus roundus**	Gp	30.5	0.0016
2	**Acrachane racemosa**	Gp	21.4	0.0048
3	***Gymnosporia royleana***	Mg	40.9	0.0976

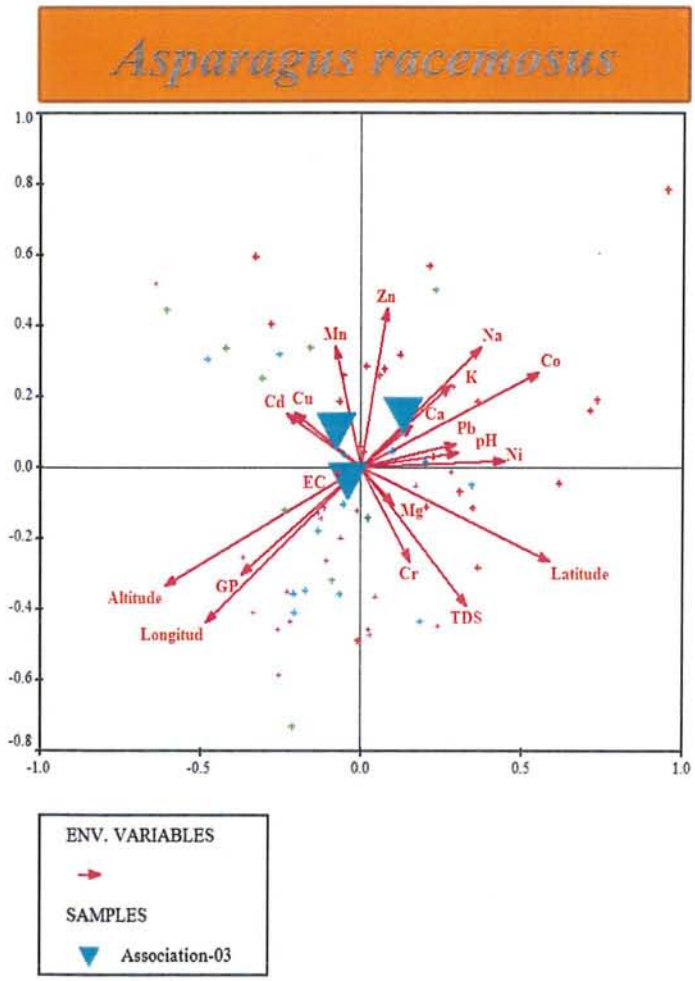

Fig 3.15 CCA (attribute plot) of *Asparagus racemosus* 1st indicator species of 03 association

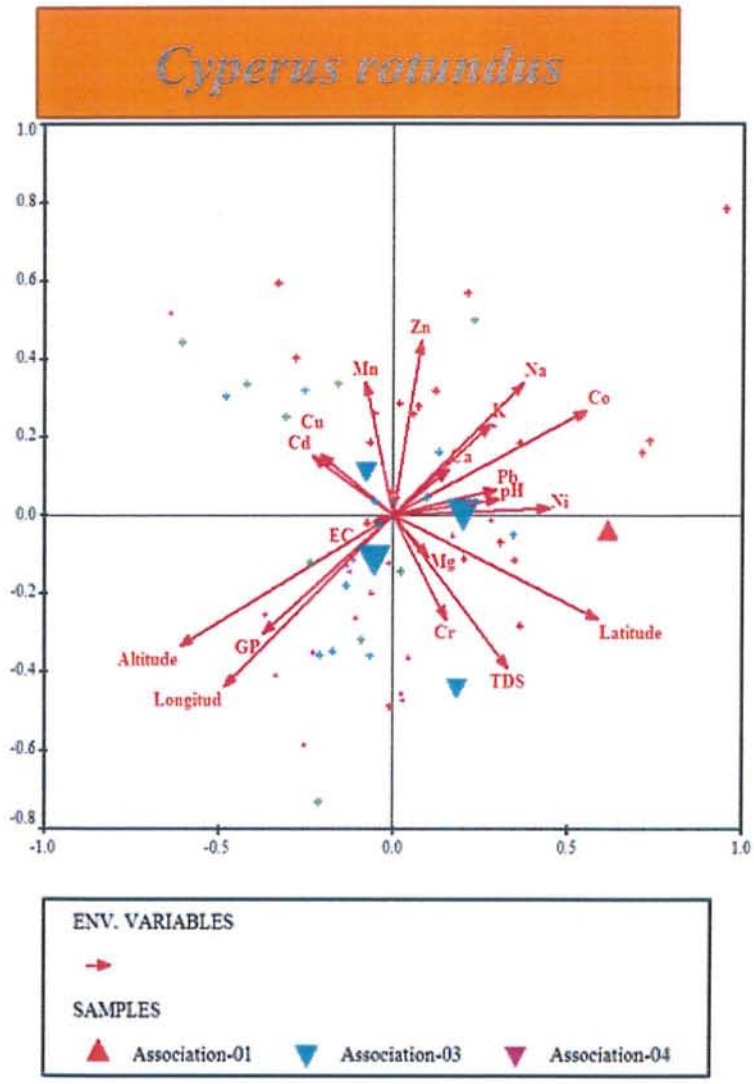

Fig 3.16 CCA (attribute plot) of *Cyperus rotundus 2nd* indicator species of 03association

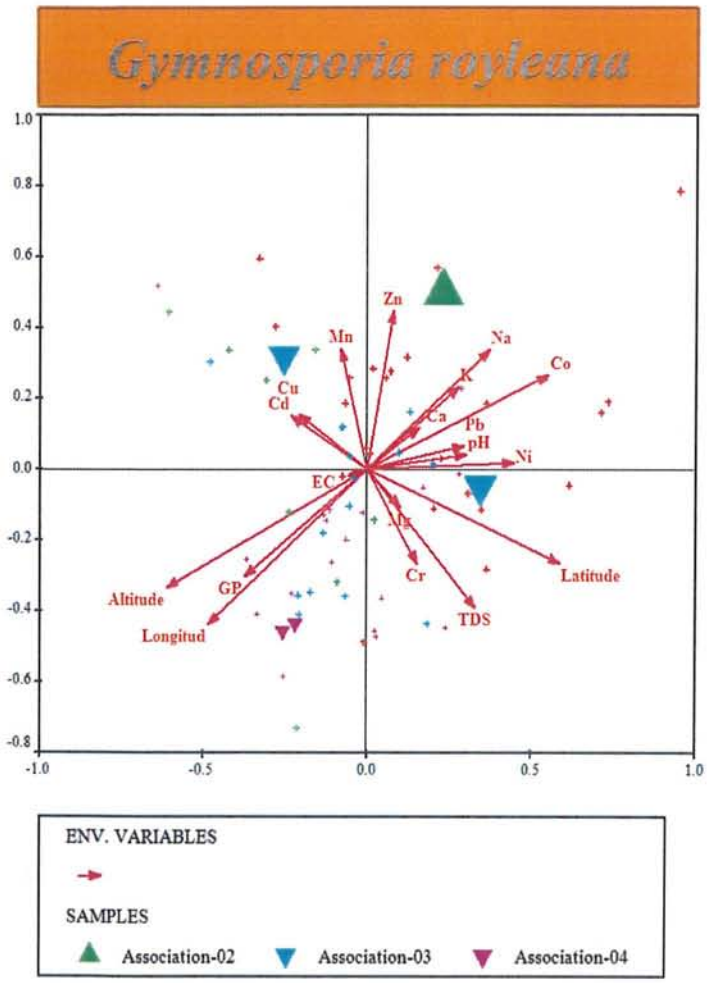

Fig 3.17 CCA (attribute plot) of *Gymnosporia royleana* 3rd indicator species of 03 association

3.6.4 04 Association ***Cymbopogon martini-Micromeria biflora-Periploca aphyla***

This is the second largest association consist on the cluster of 20 Quadrats such as, T3Q5, T9Q2, T10Q2, T7Q8, T9Q1, T9Q7, T5Q7, T8Q8, T8Q6, T10Q7, T5Q2, T6Q3, T5Q3, T6Q4, T6Q1, T5q4, T8Q5, T8Q1, T8Q2, T8Q4. Indicator species of this association are *Cymbopogon martini, Micromeria biflora and Periploca aphyla (Table 3.6).* These are the indicators of the high Magnesium concentration. *Common dominat herbs are Cymbopogon jawarancusa, Micromeria biflorand Salvia moorcraftiana.* Common dominant shrubs are *Periploca aphyla, Gymnosporea royleana and Ziziphus oxyphyla.*

Table 3.6 indicator species and its variables of 04 association

Total numbers of Quadrats= 10				
S.No	**Indicator species**	**Variables**	**IV**	**P* Value**
1	***Cymbopogon martini***	Mg	43.9	0.0850
2	***Scutelaria scandense***	Mg	50.0	0.0620
3	***Periploca aphyla***	Mg	40.9	0.0976

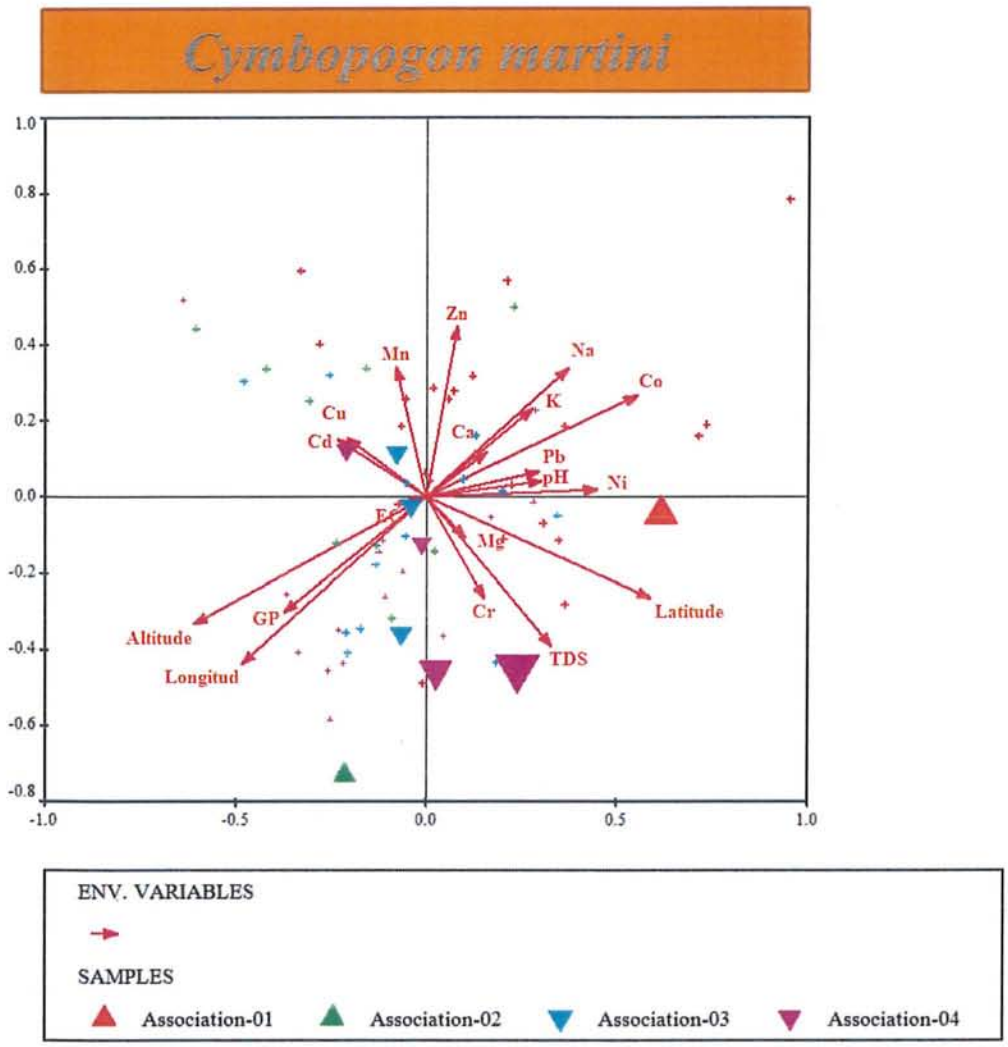

Fig 3.18 CCA (attribute plot) of *Cymbopogon martini* 1st indicator species of 04 association

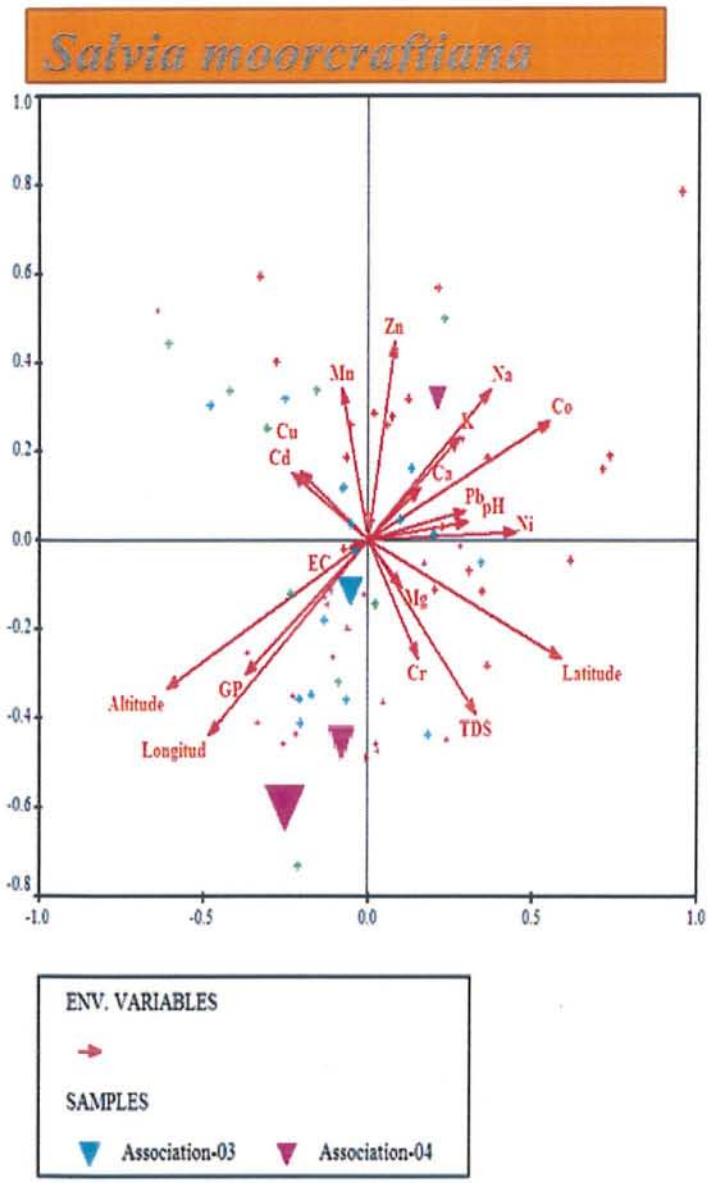

Fig 3.19 CCA (attribute plot) of *Salvia moorcraftiana* 2nd indicator species of 04 association

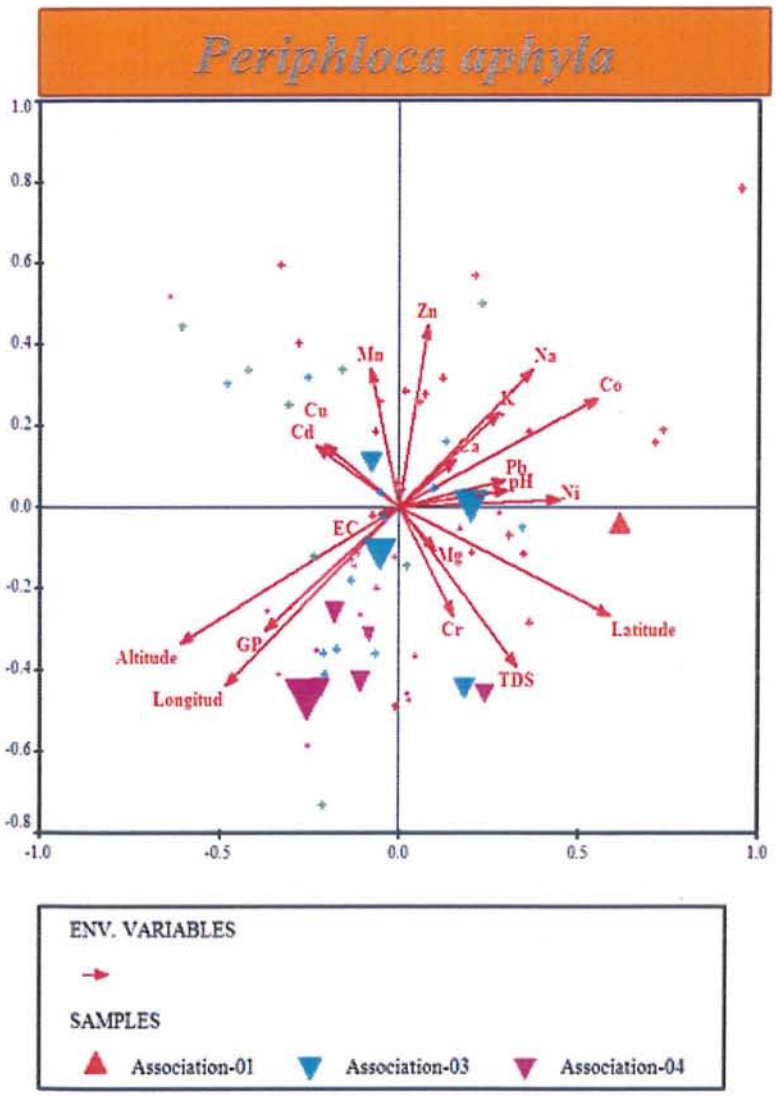

Fig 3.20 CCA (attribute plot) of *Periploca aphyla* 3rd indicator species of 04 association

CCA Plots of the Quadrats

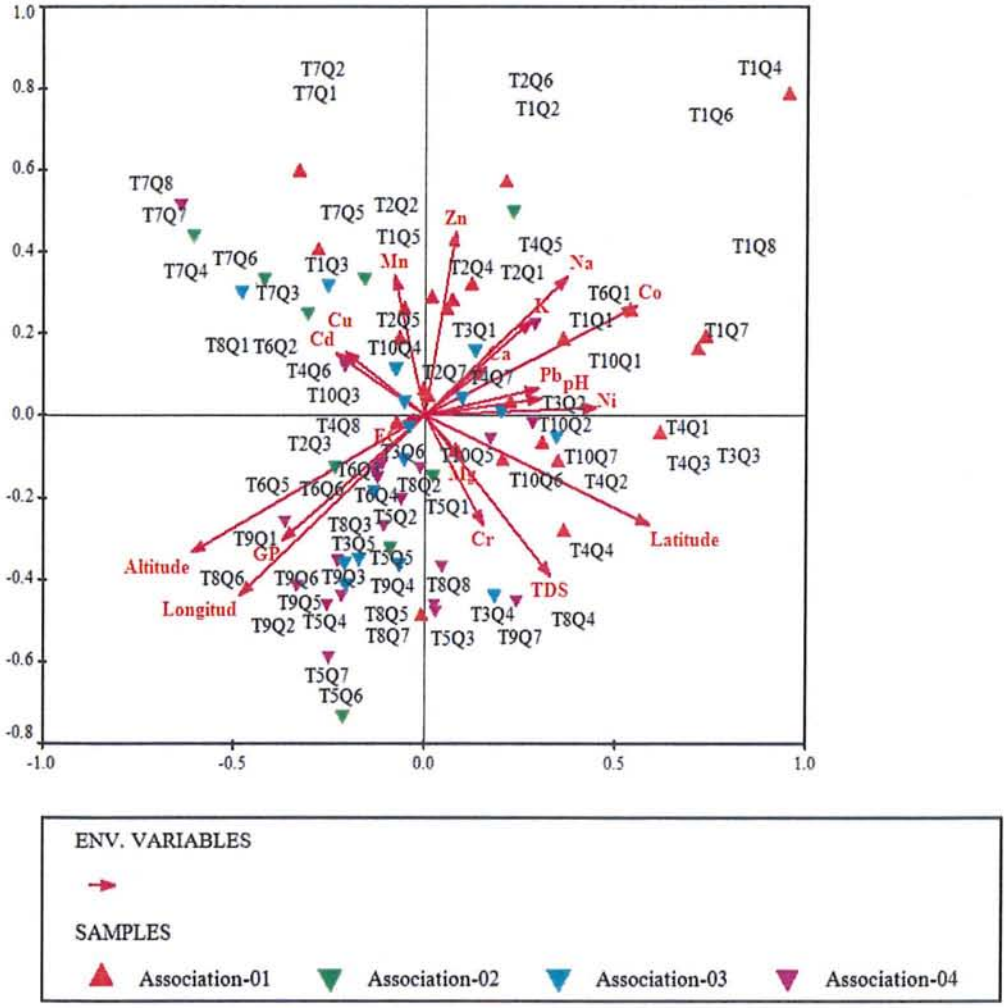

Fig 3.22 CCA plot of Quadrats plots showing distribution of 72 plant species in study area

DCA of Quadrats

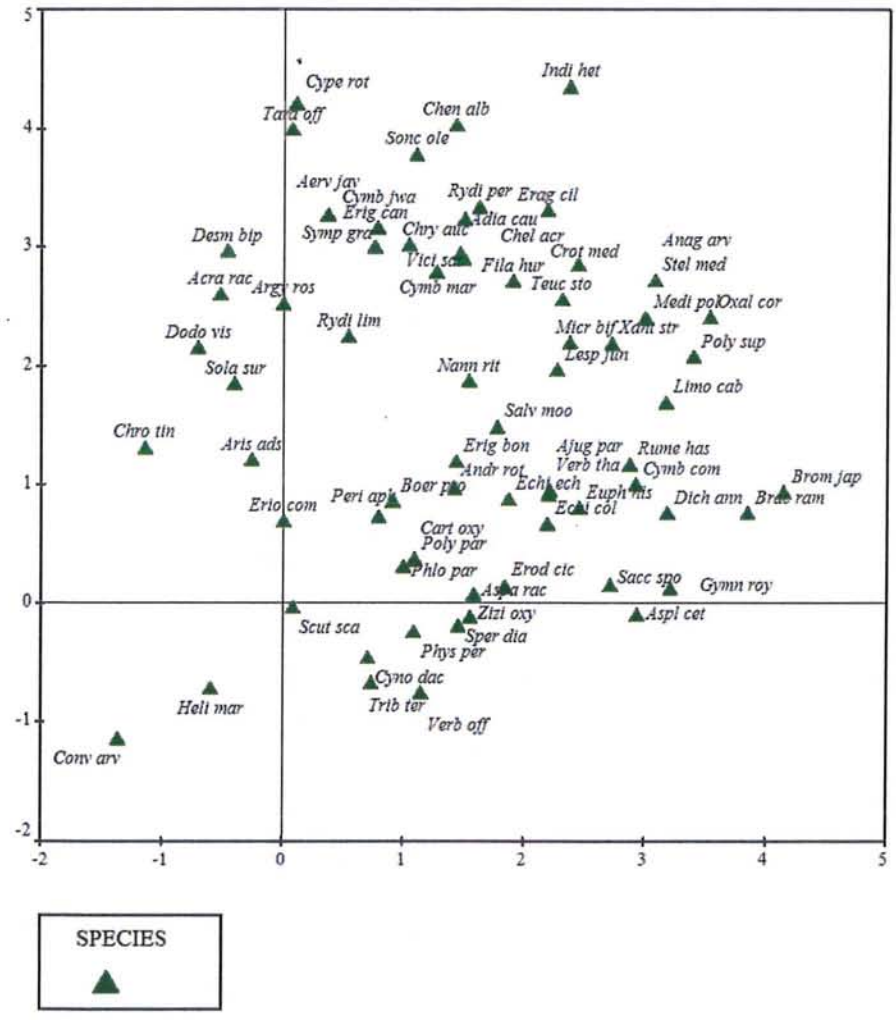

Fig 3.23 DCA plot showing distribution of 70 plant species in study area

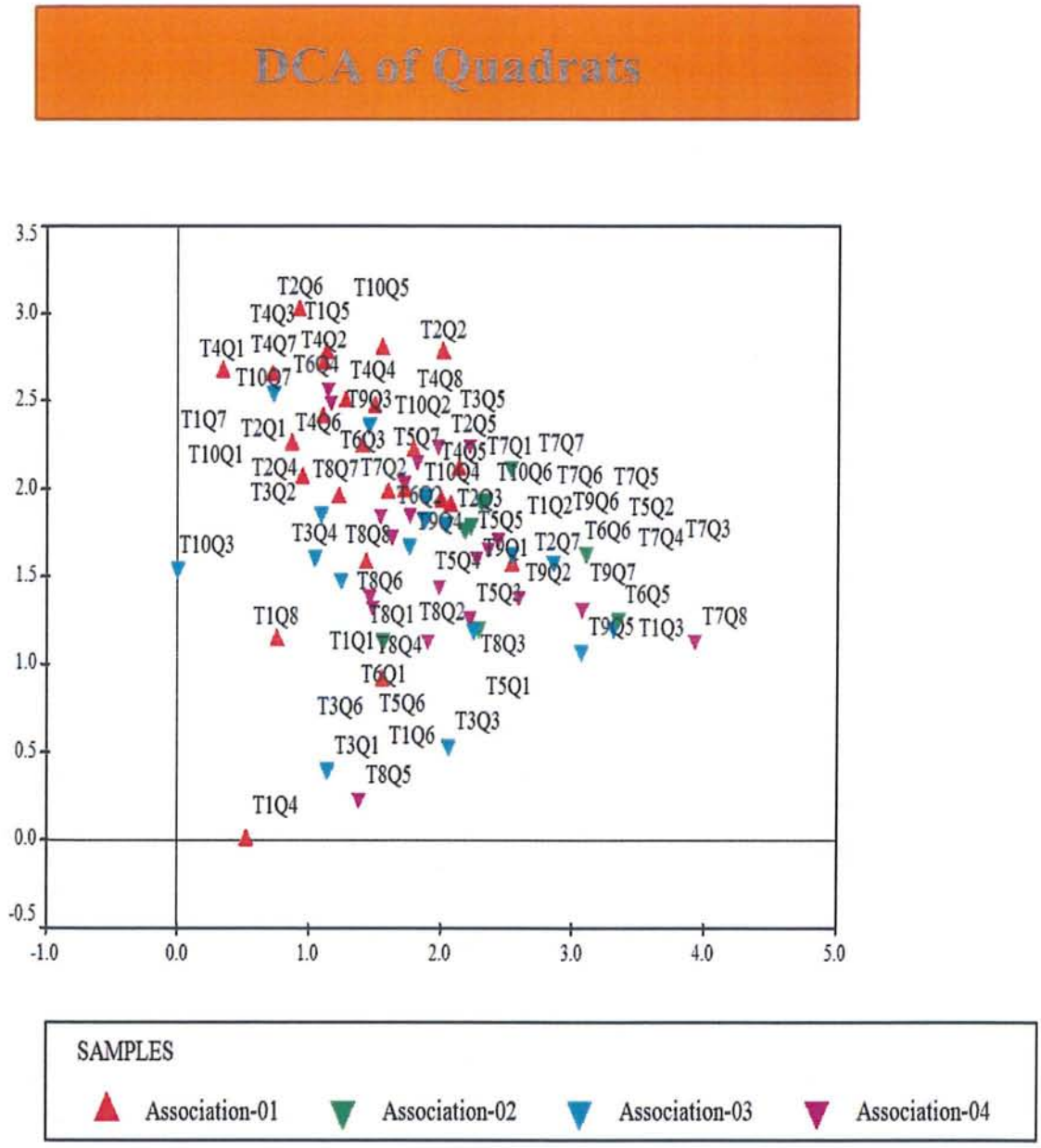

Fig 3.24 DCA plot of Quadrats plots showing distribution of 72 plant species in study area

3.7 CONSERVATION

In recent research work we have recorded *N. ritchieana* from 740 to 1540 m elevational range. Topographically individual of the species occur on the South and South west and rarely on the North-east North west while completely absent on North facing slope in wild. Distribution pattern of the species is mainly based on the light. Slopes which absorb maximum sun light *Nannorrhops* population occur in abundance. On the North facing slopes where sunlight cannot penetrate directly we have not observed a single individual of *Nannorrhops*. Furthermore it is considered that sunlight is a strong driver in the distribution of *Nannorrhops*.

3.7.1 *Determination of Geographical range of the species in Study area*

According to our questionnaire survey about 75% informants mentioned that *Nannorrhops* population directly decreases in wild with increase in human population. The species is used for number of handicrafts in study area due to which its population decreases day by day. Grazing pressure is also a significant driver for the loss of population. Consequently its populations number is decreased over the passage of time. Extent of occurrence of *N. ritchieana* in study area was 42.2 Km^2 (Fig. 3.26) and area of occupancy was 28.18 Km (Fig. 3.27) (< 500 Km^2) measured through google earth path application software. Total detail of the plant status is given in the following table.

Table 3.1. Total description of the species in Area

Name of Transect	AOO	AOO	Length of the Transects	Width of the Transects	No of Quadrats in Transects	Number of Plants in Transects	No of Stumps
T1	5.77		2.41	0.68	8	18	6
T2	1.71		0.72	0.15	7	15	3
T3	2.51		1.05	0.40	8	59	0
T4	3.14		1.41	0.49	7	14	2
T5	4.42		1.76	0.43	7	15	4
T6	3.28		1.43	0.37	7	43	11
T7	5.22		2.38	0.6	7	41	7
T8	2.13		1.3	0.31	7	56	6

T9	2.25 Km		1.1km	0.10	6	13	3
T10	0.83 km		0.35	0.07	6	30	0
	28.18	42.2Km^2	12.81	3.6	72	304	42

3.7.2 *Declaration of Conservation Status*

Through IUCN criteria's and sub- criteria's conservation status of *Nannorrhops* was expressed using hierarchical alphanumeric system of numbering. The species conservation status were assessed against criteria B. Criteria B refers to the Restricted geographic range AND severe fragmentation, continuing decline and/or extreme fluctuations in the extent of occurrence and area of occupancy. In current study the total extent of occurrence in study area was = 42.2 Km² and area of occupancy was 28.1Km^2 therefore the Endangered thresholds for EOO (<5000 km²) and AOO (<500 km²) are both met and the species is declared to be in the category of Endangered. The hierarchical alpha numeric numbering system is as follows:

EN B1 bc (i, ii,iv) +B2 bc (i,ii,iv)

- ✓ EN = Endangered
- ✓ B (Restricted geographic range AND severe fragmentation, continuing decline and/or extreme fluctuations)
- ✓ (B1) Extent of occurrence (EOO)
- ✓ (B2) Area of occupancy (AOO)
- ✓ (b) Continuing decline observed, estimated, inferred or projected in any of (i)) extent of occurrence (Aerts and Chapin III)) area of occupancy (iv) number of locations or subpopulations
- ✓ (c) Extreme fluctuations in any of (i)) extent of occurrence (Aerts and Chapin III)) area of occupancy (iv) number of locations or subpopulations

3.7.3 *Threats to species recorded during field data collection*

N. ritchieana population is decreasing due to various biotic and abiotic factors. Some major factors that are involved in the degradation are anthropogenic pressure, soil erosion, road formation, unplanned afforestation, unplanned cutting, insect attacks during blooming condition, flower plucking by kids, Seed dormancy, Grazing, uprooting by porcupine (*Hystidix histida*) and bear (*Ursus*) etc.

3.7.3.1 Anthropogenic Pressure

Human population is increasing day by day throughout the globe. It is obvious that a large population have maximum requirements. Most of these requirements they fulfill from there surrounding plant ecosystem. They use plant resources for therapeutic, fuel, construction, clothing, fibers, ropes, utensils, oil, nutritional, aesthetic as well other purposes. Due to these anthropogenic activities plant population is continuously eroding which is an alarming threat for the conservation of native flora.

3.7.3.2 Grazing pressure

It is also a serious threat to *N. ritchiana* in its wild habitat. The local communities graze goats, calf's, cows and sheep's in the wild habitat of *N. ritchian* which effects it very badly and unable to grow from 6-10 inches. Most serious grazing was observed in Takht, Sarwakai, Manro, Walai, Batai and Arang areas.

3.7.3.3 Erosion

It is also an alarming threat to *N. ritchiana* populations. In Sarkai area where *Nannorrhops* grows in wild characterized by a special type of soil of red color. The local people from adjacent villages comes to collect that soil and use it for house painting purposes. They formed gullies due to maximum collection and number of individuals have been removed.

3.7.3.4 Road formation

Roads formation also a serious problem for the destruction of *N. ritchiana* population. In Takht, Koisar, Maimola, Mian Khan Dara the population is severely eroded for the purpose of road formation.

3.7.3.5 Unplanned plantation

In the natural habitat of *N. ritchiana* Eucalyptus were planted. *Eucalyptus* plantation is a serious and risky threat for *N. ritchiana* and its associated local plant species. The water level of the study area was also downed after Eucalyptus plantation.

3.7.3.6 Unplanned cutting

It is also a serious problem for the conservation of *N. ritchiana* population. Most of the indigenous localities cut off it when producing new branches and its leaves or unmatured. The

Rainfall or precipitation is a major determinant for the size of leaf (Richards 1952). In leaf spectra classes Leptophyll is the dominant class with 28 species followed by Microphylls 16 species and Mesophyll 14. Predominance of Leptophyll leaf spectra class in associated flora of *Nannorrhops* could be linked to their preferred habitat. Second dominant class is Microphylls occurs mostly in harsh conditions, may be due to cold, heat or elevational factors. The third dominant class is Mesophyll. These are the indicator of maximum rainfall. Species belong to Mesophyll class e.g *Salvia moorcraftiana*, *Verbascum thapsus*, During spring season maximum precipitation take place in the study area which is an important source for these type of species.

Species area cure were calculated through V.5 to justify that the sample size used in the collection of the association data. For our current data species average number started from 07 at 1st transect to 70 in transect 10 quadrat 68. Sorensen average distance decreased to around 18% after sampling about 18 quadrats which shows that community of stable nature has been formed. Our study has been supported by previous literature. Species area curve was measured by (Khan et al. 2014) while studding ethno-ecological importance of plant biodiversity in mountain ecosystems with special emphasis on indicator species of a Himalayan Valley in the northern Pakistan. Species area curve also measured by (Iqbal et al. 2018) while studying phytosociological classification of weeds flora of an agro-ecological system in Malakand.

Soil play a significant role in the distribution, colonization as well as development of plants. These are the natural sites provide water, nutrients, oxygen through roots system from soil. Edaphic factors greatly influence vegetation structure, composition and functioning of ecosystem (Vallés et al. 2015). Soil factors comprises of processes associated to the synthesis of soil and its biological chemical and physical characteristics. Ecological association of plant species can be differentiated if developed on the values of indictors species (Iqbal et al. 2018). Values of indicators are the parameters shows the probable richness of species in relation to various environmental factors (Reed et al. 2008). Determination of indicators species is one of the most important and major approach and focus in the field of vegetation ecology. It was justified that topographic as well as soil factors are responsible for the synthesis of various plants association with a distinct group of indictors species. Composition, distribution, formation of association and its indictors are mostly attributed to different environmental drivers and grazing pressure. In current study number metals, nutrients present in soil such as Magnesium, Calcium, Iron, Sodium, Manganese, Cadmium, Cobalt, Zinc, Nickle, Copper, Chromium, Plumbum as well as, pH, Electrical conductivity and total dissolved solids were analyzed as factors for the evaluation of associations among plant species. Number of such type of studies have been

carried out to explore plant communities such as (Khan et al. 2014) Khan et al., (2014; Manan, 2018; Haq; 2018; Bano et al., 2018). In our current research work four different plant associations were identified with in relation to various environmental factors through cluster and two way cluster analysis PCORD version 5. The association 01 consist of 25 quadrats hosting 56 plant species out of total 70 species. Name to each association were given on the basis of its indicators species. The indicators species were determined with the help of indicator species analysis, CANOCO software. For each association three indicators were identified, two from herbs and one from shrub. Those species were considered indicators which have P* value less or equal to 0.05 and IV value more than 20 (Khan et al. 2017)(Khan *et al.*, 2017; Bano *et al.*, 2018; Haq 2018; Manan, 2018; Iqbal et al., 2018; Fatima; 2018; Anwar; 2017; Hussain; 2017). Indicators species of 01 association is *Aerva javanica*, *Spergularia diandara*, and *Dodoneae viscosa*. The indicator species analysis reflects that *Aerva javanica* is the indicator of Grazing pressure (Gp) with 25.0 IV value and 0.0068 P* Value. *Spergularia diandara* is the second indicator of 01 association on Sodium (Na) with 21.4 IV value and 0.0294 P* Value. *Dodoneae viscosa* a shrub species third indicator of 01 association on Gp with 42 IV value and 0.0004 P* Value. Dominant herb of this association are grasses such as *Cymbopogon commutatus- Bromus japonicus* and *Phlomidoschema parviflorum* and dominant shrubs are *Gymnosporia royleana, Dodonaea viscosa* and *Indigofera hetarantha.* This association shows dry climate of the study are because indicators, dominant herbs and shrubs occurs mostly in dry areas where *Nannorrhops* grow. It also show that the grazing pressure in the study area is still continuous and affects the vegetation and phytodiversity of the study area.

Erodium cicotarium-Tribulus terrestris-Gymnosporea royleana are the top most indicators of 02 association. This association consist of eleven quadrats hosting 44 plant species out of total 70 species. All indicators are strongly related with Magnesium. The indicator species analysis reflects that *Erodium cicotarium* is the indicator of Mg with 26.3 IV value and 0.0928 P* Value. *Tribulus terrestris* is the second indicator of 02 association on Mg with 40.1 IV value and 0.0804 P* Value. *Gymnosporia royleana* a shrub species third indicator of 02 association on Mg with 40.9 IV value and 0.0976 P* Value. *Medicago polymorpha, Cynodon dactylon, Lespedeza juncea* are the dominant herbs of the while *Gymnosporea royleana, Indigofera hetarantha* and *Rydingia persica* are the dominant shrubs of the 02 association. Third association is named as *Acrachane racemosa -Cyperus rotundus-Gymnosporea royleana* association with their dominant plant species. This association consist on 17 quadrats hosting 50 plant species out of total 70 species. The indicator species analysis show that *Acrachane racemosa* is the indicator of Gp with

30.5 IV value and 0.0016 P* Value. *Cyperus rotundus* is the second indicator of the 03 association on Gp with 30.5 IV value and 0.0048 P* Value. *Gymnosporea royleana* a shrub species third indicator of 01 association on Mg with 40.9 IV value and 0.0976 P* Value. Dominant herbs comprises of *Teucrium stockcianum, Dichanthium annulatum and Androsac rotundifolia* while the dominant shrubs were *Gymnosporia royleana, Periploca aphyla and Dodonaea viscosa*. Indicators and dominant herbs as well as shrub of this association also show dry habitat and extreme sort of environment mostly grazed by cattle's.

Fourth or last association named as *Cymbopogon martini-Salvia moorcraftiana -Periploca aphyla association.* This is the second largest association consist on the cluster of 20 quadrats hosting 41 plant species out of total 70 species. Indicator species analysis show that *Cymbopogon martini* is the indicator of Mg with with 43.9 IV value and 0.0850 P* Value. *Salvia moorcraftiana* is the second indicator of the 04 association on Mg with 50.030.5 IV value and0.0620 P* Value. *Periploca aphula* a shrub species third indicator of 04 association on Mg with 40.9 IV value and 0.0976 P* Value. These are the indicators of the high Magnesium concentration. Common dominant herbs are *Cymbopogon jawarancusa, and Salvia moorcraftiana* while dominant shrubs are *Periploca aphyla, Gymnosporea royleana and Ziziphus oxyphyla.* These all association showed that *Nannorrhops* and its associated flora strongly correlated with Magnesium. In all above mentioned association maximum similarity was found among associated plants species. This similarity may be due to edaphic factors such as magnesium, sodium pH of the soil etc. Our current findings strongly favored by the findings of Naseem *et al.*, (2005). According to her results that *Nannorrhops* is of restricted distribution in the soil of special ultramafic rocks of the study area district Khuzdar Baluchistan. Where the soil have Mg in maximum concentration. That's why *Nannorrhops* were classified as Mg- flora due to high contents and absorption of Mg. It play a vital role in the formation of various parts of the plants body. It is an important part of the plant body and act as an activator in the metabolism of ADP/ ATP as well as also essential for DNA and RNA. Concentration of Mg varies from one species to another and affected by several other factors such as soil, climate etc (Naseem *et al.*, 2005) Interactions between environment and its respective flora are a vital factor syecology (Leonard *et al.*, 1984; Leng *et al.*, 2006). Great progress observed in quantitative research of plant with in relation to its environment since 1980 (Chahouki and Tavili, 2012). Study on synecology has become an important focus for plant ecologists. Many researcher documented plants communities in various areas Eco-floristic zones of the world particularly in Pakistan.

Khan et al., (2017) studied plant species and communities assessment in interaction with edaphic and topographic factors, in Eelum mountain swat (Khan et al. 2017). They identified 5 plant communities in relation of soil using PCORD version 5. Similarly Bano et al., (2018), determined four plant communities using PCORD V. 5 while studding eco-floristic studies of native plants of the Beer Hills along the Indus River in the districts of Haripur and Abbottabad which excellently in the favor of our results. Manan (2018) identified four plant association using PCORD V.5 while studding conservation and ethnoecological studies of *Parrotiopsis jacquemontiana* in Dir. Haq (2018) classified the associated flora of *Alnus nitida* into four communities using PCORD V.5 while exploring ecological distribution and Syntaxonomic evaluation of Alder (*Alnus nitida*) of the Northern Pakistan. The above mentioned studies strongly support our results using PCORD V.5 for the classification of associated flora of *Parrotiopsis* and *Alnus*.

Ecologist extensively used number of ordination methods to examine the relationship between environment and vegetation. canonical correspondence analysis (CCA) are is one of the important technique of vegetation analysis within relation to environmental factors. We have justified our associations formed with the application of PCORD V.5 through CCA for plant species and quadrats. Our CCA elucidated that magnesium, grazing pressure, latitude, longitude, sodium and other edaphic factors mentioned above were the potential variables. To know relationship among species without of environmental variables we have carried out detrended correspondence analysis (DCA). It is also one of the significant approach of indirect gradient analysis and processed without in relation of the data of environmental factors (Mehmood *et al.*, 2016). DCA provide significant results for heterogenous and complex data (Hill, 1979; Gauch, 1980).

Many species of plants and animals are eroding due to increase in human population. Urbanization is one of those activities that cause loss of habitat (Czech et al., 2000). It increases the rate of extinction and frequently eroding the maximum populations of native species (Vale and Vale 1976, Luniak 1994, Marzluff, 2001). As human population increases their daily requirement directly increases. To fulfill these requirements they use plants and animals species which is an alarming threat for native species. One of these plant species which is under pressure of anthropogenic pressure is *Nannorrhops*. It is a palm species used by local communities for number of uses. The local handicrafts expert form various utensils tools and cultural items. Some of these important items are hand fans, brooms, baskets, ropes, cultural shoes, hats, hot pots, salt pots etc. It play a significant role in the livelihood of the indigenous communities of the

traditional communities. According to Iqbal *et al.*, (1991) trade of various items processed from the leaves of *Nannorrhops* was of 126 million rupees. Now days a considerable number of people are indulged in processing of various handicrafts from its leaves. Due to maximum exploitation its population decreasing day by day.

Gibbson and Spanner (1995) written about *Nannorrhops* as "We were happy when find *Nannorrhops* in its wild habitat in Pakistan. According to them that our happiness was changed by sadness when on the way we have seen that the total populations had been eliminated or severely diminished in numbers and those population which are mutilated nearly out of recognition. If someone want to see *Nannorrhops* in its wild habitat, don't late it too long. visit to Pakistan if by any mean. There might soon be few left for future generations to enjoy". The above mentioned paragraph should be a reminder for us to conserve our this local palm in its local habitat. In current study we have tried to evaluate conservation status of *Nannorrhops*. We have explored 10 different population in different areas of Bajaur where it grows in wild.

Through IUCN categories and criteria we have declared the species is endangered. As the EOO of the taxon is 42.2 Km^2 (i.e less than 5000 km^2) and area of occupancy was 28.1 Km^2 (i.e less than 500Km^2). Where is in the number of mature individuals was only 34 in wild (i.e less than 250). In current exploration we have evaluated 10 sub-populations in which 8 was severely fragmented. According to IUCN Red list categories and criteria (Anon, 2017) it should be classified in the threatened Category of Endangered. EN B1 bc (i, ii,iv) +B2 bc (i,ii,iv). Results of our current study was strongly supported by the study of Khalid and Shah, (2017) in Mohmand agency they categorized *Nannorrhops* in the category of endangered through IUCN categories and criteria (2001). They also reported that the possible reason for its decline is over exploitation by traditional communities in general while Utmankhel tribe in particular. Murad et al., (2012) documented that in Hazar Nao forest of Malakand *N. ritchieana* is on the border of extinction due to over exploitation of local population for commercial purposes. The species is of great importance and add a considerable amount to the economy of local population is well as to the budget of country. In 1954 the government of Pakistan exhibited or presented an act Known as " The Kohat Mazri Control Act, 1953". The main purpose of this act was conservation of this enigmatic and robust palm species in its natural environment district Kohat. IUCN categories and criteria's having a key role an assessment of various taxa. In Pakistan number of authors categorized various plant species into different IUCN categories. Such as *Silene longisepala* in the category of Endangered (Ali and Qaiser 2010b) classified *Astragalus gilgitensis*, (Jan and Ali 2009), Alam and Ali, (2010), *Astragalus clarkeanus* (Ali and Alam 2015) *Androsac russelli* (Jan

and Ali 2009), *Astragalus chitralensis* (Ali and Qaiser 2012), *Acacia nilotica* sub species *hemispherica* (Abbas et al. 2013), *Astragallus gahiratensis*, (Ali and Qaiser 2010a), *Convulvolus sindicus* (Abbas and Qaiser 2011a), *Cadaba heterotricha,*(Abbas et al. 2010), *Scutellaria chamaedrifolia*, (Majid et al. 2015a), *Gaillonia chitralensis* (Ali and Qaiser 2010b), *Meconopsis aculeate* (Majid et al. 2015b), *Ruellia linearibracteolata* (Abbas and Qaiser 2011b)and *Hedysarum alii* (Ali and Qaiser 2011, Haidar and Qaiser 2018) The above mentioned species were evaluated against IUCN categories and criteria's by various authors which provide a baseline to conservationist. (Abbas and Qaiser 2011a)

Fig. 4.1:Showing Spines of porcupine with the young plants of *Nannorrhops ritchiana*

Conclusion

(a) It is concluded that multivariate statistical analysis for the ecological assessment of *N. ritchiana* and its associated flora is of great importance. Multivariate statistical analysis through PCORD V.5 further elaborate about the four association and its indicator species. In our findings it is obvious that magnesium, sodium, grazing pressure, electrical conductivity, pH, total dissolved solid etc. are the strong environmental drivers for miscellaneous association and its indicator species. Floristically Poaceae, Asteraceae and Lamiaceae were the top most dominant families each with 15, 8, 8 plant species respectively. Therophyte (34 spp) was the dominant life form class followed by hemicryptophytes (18) and phanerophytes (6). Leptophyll was the dominant leaf spectra class with 28 species followed by microphylls and mesophylls with 14 and 12 species respectively. Classification of associated flora of *N. ritchiana* into different association and identification of indicator species in relation to its edaphic factors could be used for the analysis, and management of threatened flora. Similarly life form and leaf spectra identification could be used to determine micro climatic diversity of the area.

(b) In current study *N. ritchieana* was for first time recorded from the botanically unexplored Bajaur agency. The species was assessed through IUCN categories and criteria's B1 bc (i, ii,iv) +B2 bc (i,ii,iv) in the category of endangered at regional level. The population of the species facing high rate of declining in its natural or wild habitat due to anthropogenic activities, grazing pressure and uprooting of porcupine (*Hystrix histida*) and bear (*Ursus*) for food purposes.

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by Abdullah Abdullah

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