Ethnobotany of Medicinal Plants For Sustainable Utilization as Herbal Drugs in Deserts of Southern Sindh-Pakistan

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Ethnobotany of Medicinal Plants for SustainableUtilization as Herbal Drugs in Deserts of Southern Sindh-Pakistan

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Pakistan
2023

This humble effort is dedicated

With

Great love & honor

To

Esteemed and Exalted Messenger of Allah,

Our Holy Prophet

HAZRAT MUHAMMAD ﷺ

(Blessings and Peace Be Upon Him)

And his Family

The Eternal Source of Guidance for Humanity

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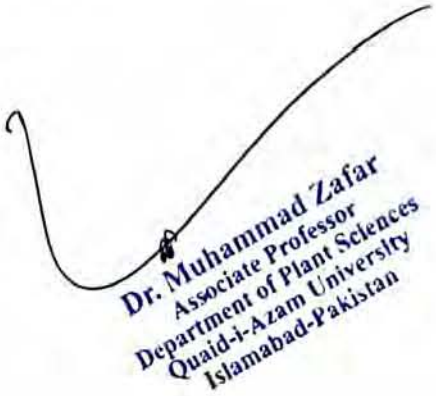

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List of Abbreviations

S. No	Abbreviation	Description
01	UNEP	United Nations Environment Program
02	NTFPs	Non-timber forest products
03	RI	Relative Importance
04	FL	Fidelity Level
05	RFC	Relative Frequency of Citation
06	UV	Use Value
07	ICF	Informant Consensus Factor
08	DCI	Disease Consensus Index
09	THPs	Traditional health practitioners
10	DS	Digestive System
11	RT	Respiratory tract
12	NS	Nervous System
13	RS	Reproductive System
14	CS	Circulatory System
15	GS	Glandular System
16	MS	Musculoskeletal System
17	SO	Sensory organs
18	US	Urinary System
19	FC	Frequency of Citation
20	GIT	Gastrointestinal tract
21	MPs	Medicinal Plant species

Abstract

The project is confined to the ethnobotanical exploration of medicinal plantsused as herbal drugs in the deserts of Southern Sindh, Pakistan and the microscopic identification. The study involved data documentation, plant collection, identification,field photography and data analyses using qualitative and quantitative ethnobotanical techniques (Use reports (UR), Use value (UV) and Relative frequency of citation (RFC); and microscopic characterization of pollen using electron microscopy. In total,124 important medicinal plant species belonging to 46 families were reported for the treatment of veterinary disorders and Human diseases. A total of 57 medicinal plant species of 29 families were reported by 186 local informants for the treatment of various veterinary disorders while a total of 79 medicinal plants belonging to 48 families were documented to treat chronic human disorders. Different plant families with various species were reported for veterinary disorders including Fabaceae (06 species) followed by Amaranthaceae, Convolvulaceae and Cucurbitaceae (04 species each) whereas Asteraceae (09 species) followed by Fabaceae (8 species) and Solanaceae (06 species) were found most reported plant species used against human diseases. The most dominant life form was herbs whereas it was reported in the current study that the most used common methods of utilization of recipes were decoction, powder, and juices. Among the plants used in veterinary disorders, *Senna italica* Mill., *Solanum surrattense* Burm. f., *Fagonia bruguieri* DC., *Fumaria indica* (Hausskn.) Pugsley, *Mukia medraspatana* (L.) M.Roem., *Opuntia dillenii* (Ker Gawl.)Haw., *Tamarix aphylla* (L.) H.Karst. and *Tribulus terrestris* L. were commonly reported while for the treatment of human diseases. We also examined the palynological characters potentially to be used for the species delimitation of selected medicinal plants via acetolysis were examined using scanning electron microscopy. Medicinal species can be characterized by small to large sized pollen morphotypes sustainable development of new herbal drugs based upon traditional recipes. presenting diverse types of pollen shapes, prolate spheroidal, spheroidal, prolate, sub- prolate, sub-oblate and prolate and oblate. The present study highlights the baseline data for further experimental elucidation and validation through phytochemical and pharmacological research, which could be of develop interest in the design of sustainable development of new herbal drugs based upon traditional recipes.

1.1 Ethnobotany of Medicinal Plants

Ethnobotany of medicinal plants is a rapidly growing science, attracting people with widely varying academic background and interests. It is still mostly connected to rural community economic development. It is pursued to determine the potential economic value of various medicinal plants with special emphasis on ethnomedicine and sustainable utilization of medicinal plants as herbal drugs. There isan increasing interest to explore herbal drugs from plants and animals as potential source of lifesaving drugs. The ethnobotanical discoveries might serve as a foundation for identifying materials that can be usefully evaluated for chemical activity employing bio directed assays. This method to the development of novel medicines is severely neglected today, to the cost of human health, and various new tactics for future improvements in herbal drug discovery might be considered. Botanical trainingis required to preserve and identify the plant specimens; ethnographic education is necessary to know cultural concepts surrounding plants perspective; and linguistic training is required to have a comprehensive command of indigenous uses of natural products and to understand native morphology, syntax, and semantics of rural culture. Indigenous peoples, on the other hand, are generally hesitant to share their expertise with outsiders. Ethnobotany provides numerous linked and interdisciplinary disciplines incorporating features such as ethnomedicine, ethnoarchaeology, ethnobryology, ethnoecology, ethnoagriculture, ethnonarcotics, and ethnopharmacology in conjunction with traditional areas of study (Pandey and Tripathi, 2017).

The use of ethnobotany to medicinal plants for human wellbeing necessitates data on socio-economic elements of medicinal plants for long-term use, environmental effect, or biodiversity protection. ethical requirements are the preservation of the knowledge base, capacity building among indigenous peoples, andequitable sharing of income resulting from commercial use of indigenous knowledge. In present scientific era, ethnobotany research requires data accuracy, statistical assistance, and quantitative or semiquantitative analysis of field observations (Jain, 2004).

1.2 Ethnobotany of Medicinal plants in the Modern World

Ethnobotany is a branch of botany that studies the interactions between humans and medicinal plants to find a long-term solution. It is situated at the

crossroads of natural and social sciences. Ethnobotany of medicinal plants in modern world have provided a great data on folk medicine and medicinal plants of different ecological regions. In various developed countries, increasing demand of plant-based medicines, the ethnobotany has provided ground to investigate the plants with highly medicinal properties. Plant species ranges from 10,000 to 53,000 are used in traditional medicine worldwide (McChesney et al., 2007), contributing to the discovery of modern drugs (Lahlou, 2013). The plant based natural product have been encouraged by scientists because of their lesser side effects and cost effective. Many ethnobotanical documentation of medicinal plants in developed countries have revealed that knowledge of traditional herbal medicine was transferred from elder to their younger generations (Garnatje et al., 2017; Shaheen et al., 2014).

In developed countries the medicinal plants explored through ethnobotany have always been a crucial source of natural drugs for humans. Ethnobotany has been applied in a variety of novel ways for the creation of herbal medicines in many parts of the modern world. Bioprospecting for novel food crops and novel medicines with a botanical origin has traditionally depended on ethnobotanical data. Ethnobotanically driven bioprospecting has grown more powerful than random research for finding bioactive compounds from therapeutic plants. Aspirin was developed from (*Filipendula ulmaria*), codeine and papaverine (*Papaver somniferum*), colchicine (*Colchicum autumnale*); digoxin and digitoxin (*Digitalis purpurea*); tetrahydro- cannabinol and cannabidiol (*Cannabis sativa*) and from *Catharanthus* vinblastine and vincristine are some of the most well-known plant based classical drugs developed through ethnobotanical prospects (Garnatje et al., 2017; Parasuraman, 2018). Theinitial proof for paclitaxel's anticancer effects came from its well-known general toxicity, which was based on ethnobotanical data. The success of this anticancermedicine demonstrates the prospective significance of ethnobotanical surveys in medication development of plant products. Based on ethnobotanical data from traditional Chinese medicine, oseltamivir was synthesized from *Illicium verum* during the recent avian flu outbreak. Artemisinin (*Artemisia annua* L.) was isolated anddeveloped as a potent antimalarial medicine as a result of ethnobotanical studies of medicinal herbs, and its importance was perceive with the Nobel Prize of Medicine in 2015 (Garnatje et al., 2017; Tu, 2011).

1.3 Ethnobotany Medicinal plants in Africa

The ethnobotanical practices of medicinal plants are well developed among the indigenous people of African countries with special emphasis on the sustainable utilization of medicinal plants resources. Indigenous African tribes typically use dozens of medicinal plants as sources of ethnomedicine from edible fruits, leaves, roots and tubers, barks, flowers, and gums for primary healthcare. In many African countries, the medicinal plants documented through ethnobotanical explorations are continuously documented and have got importance in sustainable development of herbal drugs (Elansary et al., 2015; Mander et al., 2007; Nolan and Turner, 2011). In South Africa, traditional plant users are estimated at ~27 million people (Mander et al., 2007), with an average use frequency of traditional medicine estimated at approximately five times a year and an average mass of 157 g of plant materials used per treatment (Mander et al., 2006). This short statistic indicates the strong relationship of traditional medicine firmly entrenched with cultural practice in Africancountries. In literature from African countries, it is reported that plant parts may be chewed, often as sources of medicine; others are incorporated into the diet such as fruit or vegetable. In Africa, Indigenous and local communities have devised cultural practices embedded in religious ceremonies that have maintained species and habitats of biocultural importance through indigenous and local knowledge systems (Berkes, 2012).

In African communities, the indigenous and local Knowledge (ILK) consist of a body of knowledge shaped by ethnobotanical practices, institutions and worldviews forming a nested "knowledge-practice-belief" for the contemporary biodiversity management and conservation through sustainable utilization (Berkes, 2012). In most of the African countries, the sustainable utilization of medicinal plants provides a plethora of ecosystem services to support human needs for food, medicines, livelihoods, and other cultural activities (Dargavel, 2006). Among various countries, the plant resources are sustained through cultural practices where plant users collect and harvest materials selectively using locally adapted management strategies (Rasethe et al. 2013), that is also important for the conservation of biodiversity, rare species, ecological processes, and sustainable harvesting practices (Berkes et al.,2000). The application of Ethnobotany through cultural practices can help to

strengthen cultural values compatible with conservation to sustain plant resources for biodiversity and to support human needs (Cunningham, 2001).

1.4 Ethnobotany of Medicinal plants in South Asia

The documentation of ethnobotanical use of medicinal plants is commonly found in South Asia. In Asia, the practices of traditional medicine are based upon continuously conducted ethnobotanical surveys and resulted in the form of various healing systems. Among such healthcare systems, Ayurveda is common in Himalayas of India and Pakistan; Jamu in Indonesia; Chinese traditional medicine system in China; Kampo system in Japan; Sowa Rigpa in Bhutan; Thai medicine system in Thailand and Herbal Medicine in various South Asian countries like Bangladesh,Pakistan, and India. Historically, the ethnobotanical uses of medicinal plants in ritual ceremonies, medicine, food, fuel, and as agricultural tools is commonly mentioned in south Asian literature and in various religious books published such as Rigveda, Atharvaveda, Upanishads, Mahabharata and Puranas (Omidvar and Dayhoff, 1997; Rahman et al., 2019). Although, the concepts of ethnobotany in South Asia including India were well explained in 1870s (Merlin, 2000) but from 16th century onwards, many researchers took a firm rein in active herbal drug development and their sustainable utilization. Among such historic works, Materia Medica of Hindoastan-20 dealt mainly with plants and drugs of established indigenous systems of Indian medicine (Ahmed et al., 2017). In continuity to this, in literature a study was reported on the ethnobotany of *Ziziphus spina-christi* in the Middle East with focus on diversified uses and recipes with reference to historical, religious, philosophical, linguistical and pharmacological for the treatments various diseases among Muslims, Jews, and Christians. It was highlighted that this is the only tree considered as holy, in addition to the status of a “sacred tree" by the Muslims, it also has a special status of a “blessed tree" in the Druze religion (Dafni et al., 2005; Dikshit et al., 2016).

In Asian countries, the medicinal plants explored through ethnobotanical surveys account for 50% export of medicinal plants and global earnings of 45% from folk medicines (Astutik et al., 2019). The representation of Asian region as most important center regarding ethnobotanical knowledge of medicinal plant species for the treatment various diseases (Kunwar and Bussmann, 2008). The medicinal plants uses in developing and poor countries of Asia is widely practiced in the healthcare systems of folk medication. Medicinal plants using for export and domestic

purpose is growing wild representing greatest volume in developing nations of Asia (Ong et al., 2018).

In India, the 3000 years old medicinal ethnobotanical heritage is based on plants and indigenous knowledge of medicinal plants and their linkages with tradition and folklores from previous literature (Anbazhakan et al., 2007). Indian tribes conserved the ethnobotanical knowledge about the medicinal plants for their sustainable utilization and herbal drug development. This knowledge is broadly used for the treating common ailments transferred from generation to generation through word of mouth (Dwivedi et al., 2008). In India, several historic and deeply developed healing traditions (Ayurveda, naturopathy, Unani, Siddha, Sowa-Rigpa, and Homeopathy) are practiced and explored through ethnobotanical surveys (Rupani and Chavez, 2018). It is reported in various studies that Ayurvedic therapies are based on complex herbal compounds, minerals, and metal substances (Joshi et al., 2017). Naturopathy is another systemic approach to healing, which incorporates prevention from diseases via diet and lifestyle, along with addressing social, environmental, genetic, and mental components to health (Fleming and Gutknecht, 2010). The emphasis is on enabling the body to heal itself. Botanical medicine is a component of this tradition. Unani medicine, like Western medicine, is thought to have been established by the Greek philosopher Hippocrates, with contributions by Galen and Aristotle (Ansari et al., 2018). Siddha medicine comes from Tamil culture in South India. The foundational concept is that a healthy soul can be achieved only through a healthy body as such, diet, and yoga meditation as mind–body practices are fundamental to this healing system (Sathasivampillai et al., 2018).

In Bangladesh, the traditional medicine development through ethnobotany has long history based upon Ayurvedic, folk medicine and homeopathic systems. The most practiced system in country is the system of folk medicine and it is very well practiced among the practitioners known as Kavirajes or Vaidyas. In link to this, various ethnobotanical studies have been carried out (Faruque et al., 2018; Rahmatullah et al., 2010) that have resulted in well-developed herbal treatment system. The medicinal practitioners of various tribes in the country have their own system which is closely linked with system of Kavirajes of folk medicine. The basic similarity between the typical Kavirajes and practitioners of tribal system are similar in terms most diseases

treatment by use of medicinal plants. The indigenous knowledge of folk tribal therapeutic healers is preserved through ethnic dialects, and their methods of treatment passed from one generation to another is commonly explored and documented through rigorous ethnobotanical surveys (Keya and Rahman, 2017; Rahmatullah et al., 2012).

In Asia, China is a multi-racial country with more than 56 nationalities, of which 55 in over 18 provinces are officially recognized as ethnic communities with reference to ethnobotanical knowledge. Various traditional ethnic medicines from indigenous communities have made the great Traditional Chinese Medicine (TCM) (Huai and Pei, 2002). The ethnobotanical studies in china from numerous socio- linguistic groups have played a crucial role for community health in the indigenous areas with sustainable utilization of biodiversity. Through many studies it is observed that China's 55 minority socio-linguistic groups are recognized to utilize more speciesof medicinal plants as compared to the Traditional Chinese Medicine (TCM) system of the dominant population. There have been approximately 7,000 to 8,000 documented medicinal plant species found in the ethnobotanical literature from minority communities of china and about 4,758 medicinal plants species are commonly reported in in TCM (Yang et al., 2014). In present, the gathering ofmedicinal plants also provides an important livelihood activity for many indigenous communities in China (Pei, 2007).

1.5 Ethnobotany of Medicinal plants in Pakistan

Pakistan has a distinctive topography, with the Hindukush Himalayas and Karakorum mountains, with elevations ranging from 0 to 8611 metres above sea level, resulting in a wide range of climate zones and floral richness. Pakistan contains about 6,000 different types of higher plants (Ali & Qaiser, 1986; Gilani et 2014). Out of these, more than half (approximately 3000 species) are reported from Northern regions (Ahmed et al. 2014). Overall, 600 to 700 valued medicinal plant species have been reported and 70% of these species are estimated to be uni-regional and about 30% bi- or pluri-regional (Sharif et al. 2018). It is estimated that at least 12% of the reported plant species is used as herbal medicinal and several plants are exported as herbal crude drugs.

Pakistan is a country divided into different regions including Azad Jammu and Kashmir, Gilgit Baltistan (GB), Punjab, Khyber Pakhtunkhwa (KP), Baluchistan, and Sindh. The ethnobotanical knowledge of medicinal plants seems to be essential for conservation and sustainable utilization and development in Pakistan. In Pakistan, Ethnobotany is now well recognized discipline and explored various eminent medicinal plant species for herbal drug development and their sustainable utilization but still many regions such as deserts and arid lands are unexplored. In Northern regions, the indigenous societies of remote areas and mountainous regions has been practicing the traditional medicines from many generations. Far remote areas ofPakistan, knowledge of traditional herbal medicine helps the researchers to explorethe new medicinal plants with precious pharmacological properties. Still many rural areas of Pakistan, local communities are practicing the old traditional system of medicines. Mostly Traditional health practitioners (THPs) locally called *Hakims* in rural areas and villages, practices the herbal traditional medicines. These *hakims* sale profitable medicinal plants and they get knowledge from their elders Mahmood et al., (2011). Many ethnobotanical studies on medicinal plants has been conducted in various regions of Northern Pakistan (KP and GB), Azad and Jammu Kashmir, Plain areas of Punjab, Baluchistan, and Sindh but majority of the studies are conducted in Northern mountainous regions of Pakistan while, southern plain regions of Pakistan either a smaller number of studies or still unexplored. Among such regions, thedeserts of Southern regions of Sindh are not explored yet.

In literature from Azad and Jammu Kashmir, Khan et al., (2010) reported 169 species that are used for the purpose of medication and food and highlighted that important plant species need sustainability and conservation measures. In another study, Mahmood et al., (2011) reported some species such as *Achyranthes aspera*, *Adiantum incisum Aerva javanica*, *Argemone mexicana* and *Butea monosperma* commonly used against human disorders. Qureshi and Shaheen, (2013) also reported ethnobotany of 200 plant species from tehsil Kotli Sattain. Amjad and Arshad, (2014) reported different uses of medicinal plant species from Kotli.

In Khyber Pakhtunkhwa (KP), Ahmad et al., (2011) reported 140 plant species among rural communities of Swat used as ethnomedicine. Murad et al., (2012) compiled an inventory of 90 important plant species from Hazar Nao forests of Malakand used as was accomplished to collect the folk ethnomedicinal knowledge of 90 reported species. Shah et al., (2013) reported 131 important plant species for the treatment of various ailments in, Khyber Pakhtunkhwa and Punjab; Qaisar et al., (2013) conducted a study on economically important 88 medicinal plant species from Waziristan Agency, Pakistan. In another study, Hadi and Ibrar, (2013) from district Chitral reported 29 species from 16 families for treatment of various disorders. Ahmad et al., (2014) compiled an inventory of 50 important plant species from Chail valley Swat, Pakistan; Kayani et al., (2014) reported 120 medicinal plant species for respiratory disorders in Gallies of Abbottabad; In continuity to previous practices, Malik et al., (2018) reported 80 medicinal plant species from Northern regions for treatment of hypertension.

In various regions of Punjab many ethnobotanical studies on medicinal plants have been carried out. Zareen et al., (2013) conducted ethnomedicinal studies in the Central Punjab and described 35 plants species belong to 22 families that were commonly used by the local people for herbal medicine, shelter, and fodder. In Cholistan Desert, the ethnobotany of *Calatropis procera* was reported to use against different diseases (snake bite, wounds, swellings, and veterinary ailments) by the local inhabitants. It is an active remedial potential can be ascribed to contains higheramount of secondary metabolites concentration by this plant (Azhar et al., 2014). Naz and Tamoor-ul-Hassan, (2014) studied in detailed the medicinal plant species with taxonomical perspective, reported 80 plants species from Attock, Pakistan against

treatment of diverse ailments including asthma, piles, cancer, skin diseases, diabetes, cough, inflammation, kidney stones, Jaundice etc. The ethnobotanical knowledge was also documented by Khan and Musharaf in (2014) in Kotal wildlife park where 211 plant species were reported used as medicine, food, fodder, and shelter). Fatima et al. (2017) reported ethnomedicinal uses of 72 plant species for treating oral diseases.

Baluchistan is largest province of Pakistan, but a few ethnobotanical studies has been published from indigenous communities. In literature, Bibi et al. (2014) investigated 100 medicinal plant species commonly used herbal medications in district Mastung where traditional medicinal knowledge is depleting day by day and the conservation of this knowledge is needed. In another study, 26 medicinal species from 13 plant families and 20 genera were reported in some villages of Zarghoon, Juniper ecosystem area (Baluchistan). These plants were used commonly by the local people for treatment of different diseases (Bazai et al., 2013).

Although Sindh province of Pakistan has rich diversity of medicinal plants and culturally important indigenous people that have very strong cultural link with medicinal plants used as herbal drugs, but the ethnobotanical documentation of important and precious medicinal plant species still lacking behind. In literature, only a few studies have been reported from Northern regions of Sindh (Bhatti et al., 1998; Bhatti et al., 2001; Panhwar and Abro, 2007). In continuity to this, (Qureshi et al., 2010) reported the 63 herbs from Northern deserts of Sindh while in another study, ethnomedicinal data on 51 plant species from Nara desert was documented (Qureshi and Bhatti, 2008). In another study, Yaseen et al. (2015) reported 87 species of ethnobotanical importance from Thar desert.

1.6 Medicinal Plants in Sindh

Sindh has arid or semi-arid climate, through its coastal and riverine forests. There are fresh water lakes, mountains, and deserts and the irrigated Indus valley with diversity of important plant species used as food, medicine and shelter (Hussain et al., 2012). The medicinal flora of Sindh is characterized with therophytes and most of the tree flora is riverain, growing along rivers, especially the Deserts. In most of the desert lands, arid and semi-arid environment bushy growth form of medicinal plants isfound to be dominant. Except for the irrigated Indus Valley, the region is largely dry with little vegetation. Sindh is home to a varied flora, according to a research. According to the study, diverse flora has a critical role in ethnic groups' survival inthe region. Various environments, including hills, sand mounds, and sloping plains,are said to be home to a range of plant species that are abundant during the monsoon but begin to dry up as the season finishes. Only the drought-resistant and deep-rooted perennials survive after the rain. Among such species, *Acacia Senegal*, *Aerva javanica*, *Commiphora wightii*, *Calligonum polygonoides Dipcadi erythraeum Euphorbia caducifolia, Prosopis juliflora*, *Rivea hypocraterformis* and *Rhynchosia schimperi*, are commonly found.

1.7 Deserts of Southern Sindh

In Sindh province, the deserts can be grouped into two namely NorthernDeserts (Nara desert) and Southern Deserts. Thar desert and Acchro thar desert are two of Sindh's southern deserts. The Achro Thar is surrounded by the Nara and IndianThar deserts. The topography of Nara and Achro Thar is defined by plain regions, lakes and sand dunes hills (Qureshi and Bhatti, 2005). It covers four district ofProvince Sindh; Badin, Mirpur Khas, Tharparkar and Umerkot. Desert is bordered in the south-east by India's Barmer and Jaisalmer, and in the south by India's Rann Kachh, while the Thar Desert's Mirpur Khas area is bordered by Rajasthan (Yaseen et al., 2015). This topography is a phytogeographic extension of the xerophytic Sahara- Sindian region. To the south, the Rann of Kutch is a sandy salt marsh, to the west, the Nara canal runs along the western border, and to the east, the Rajasthan Desert, India. Most people think that these southern deserts have been existing for 10,000 years. Thetropical thorn deserts cover 2.65 million hectares classified as xerophilous, scrub

vegetation, and a variety of other plants make up the limited vegetation (Kalhoro, 2018).

In southern deserts, three physical characteristics are particularly common: x steep slopes, huge low flat plains and sandy hills. All of deserts have, sand dunes, slopes and undulating plains as well as salty regions and some low-lying worn Rocky Mountains. In Sindh's southern deserts, sand dunes microhabitats are the most conspicuous feature of desert. A long swath of sand hills, some of which reach heights of over 500 feet, runs parallel to one another and from northeast to southwest. The sand dune's original development appears to have been perpendicular to the southwest monsoon current's path. However, the monsoon stream eventually created longitudinal ridges that ran parallel with each other. Their height varies from a few meters and over 100 meters. Slopes are the sand dunes' central section (Chandio et al.,2018).

The majority of plant species growing on the flanks of the characteristic flat terrain found in all of Pakistan's deserts is the foot or base of the sand dunes. The most common alluvial soil components in depressions are clay and silt. A forest habitat exists in low-lying flat regions near the sand dunes, which sustain diversity of tall and ancient trees. These trees provide shade for animals during the warmest hours of the day. Saline lands formed as a result of stagnant rainwater on the flat plains of the depressions. Rainfall collected in depressions in neighboring valleys, bringing alluvial soil with it. Water evaporation from larger depressions causes salt deposition and the development of sodic soils. A number of saltwater lakes may be found in the region. Grass, reeds, and cattails dominate the ecosystem. These plants are examples of emergent vegetation, which has roots in water-soaked soil and leaves that cling to the surface of the water. Some deserts have steep ranges, such as the Tharparkar Desert's Karoonjhar Hills. These hills' highest point may reach 1169 feet above sea level (Rajpar et al., 2019; Yaseen et al., 2019).

Plate 1: Panoramic Views in Desert of Sindh **(A)** Acharo thar, **(B)** Islam Kot

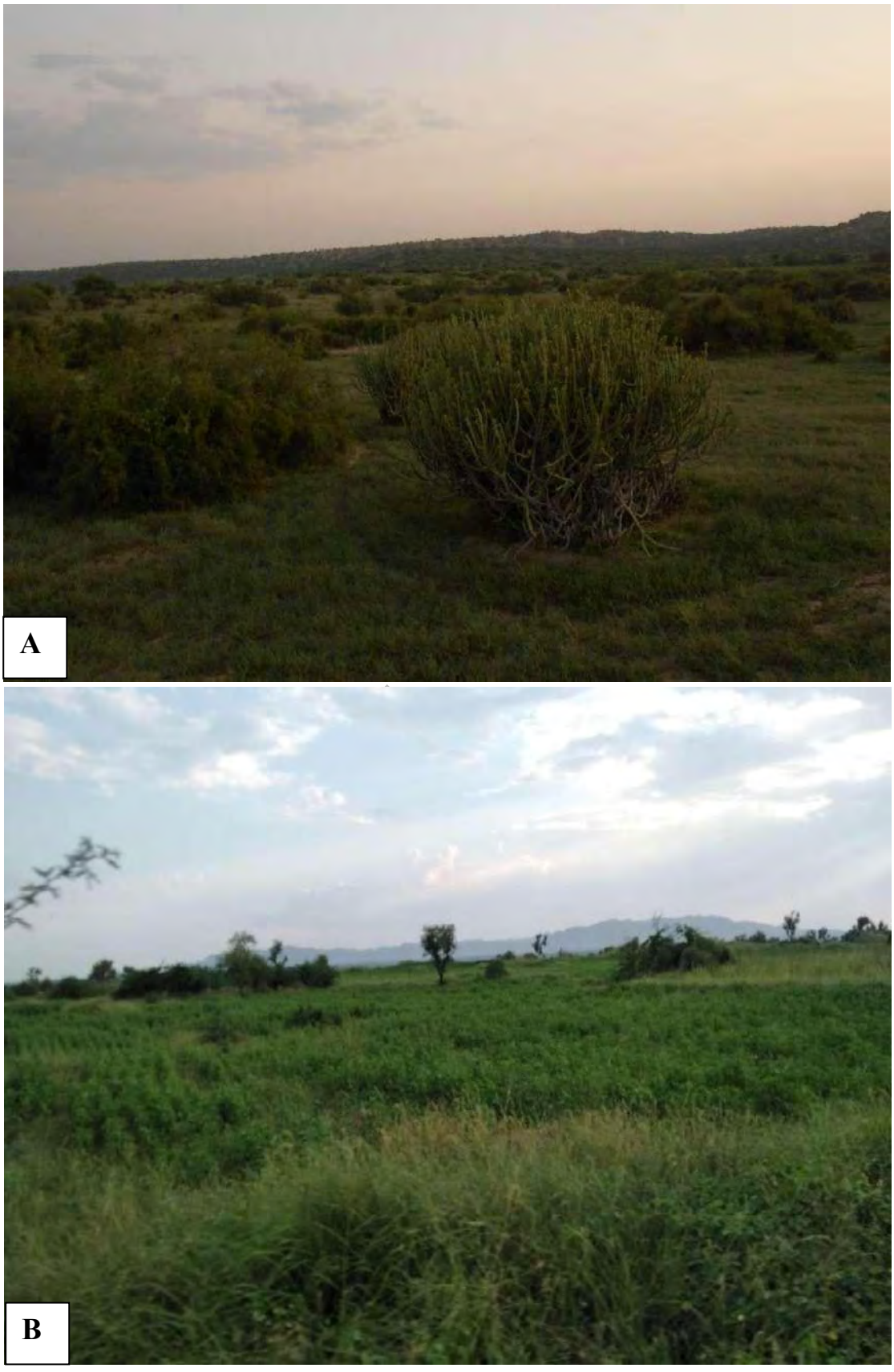


Plate 2: Diversity of Medicinal Plant in Deserts **(A)** Mithi, **(B)** Chachroo

Plate 3: Local indigenous population **(A)** Dewsi village, **(B)** Marvi Kohah

1.8 Pollen Micro-morphology

Palynology is the science of pollen grains and spores. Palynomorphs are all organic walled microfossils including grains and spores. Palynological studies are not only helpful in solving in many taxonomic problems, they are also beneficial in determining the incidence of pollen that causes pollinosis (Ganga et al., 2016). One of the most dominant character of spores and pollens are they are microscopic and are unable to destroy easily (Nugroho, 2018). According to palynological data, that provide correct identification for the closely related taxa. Pollen morphological data helps to the identification of taxa at a very specific level. Pollen grains the male gametophytic structure of the seed plants forming a dispersal unit which were involved in fertilization show remarkable morphological diversity, which reflected high variation in shape, size, exine sculpturing and many other pollen wall characteristics. The pollen wall is made up of two different layers; the outer covering layer is exine predominantly composed of sporopollenin, while the inner layer intine consists of pecto-cellulosic materials (Prieu et al., 2016).

Angiospermic group of flowering plants are characterized by diverse varietyof shapes and patterns which is clearly expressed in their pollen morphology (Mander, 2016). In life cycle of all seed plants pollen plays an important role and consequently pollen morphological characters are useful in study of reproductive biology of plant groups with key phylogenetic position and their evolution as well as for analyzing their molecular data. (Bolinder et al., 2015; Bolinder et al., 2016; Sauquet and Le Thomas, 2003). Pollen morphology play significant role in depicting associationamong species at various taxonomic levels (Ahmad et al., 2018). The key character of pollen grain that have taxonomic value is size, shape, aperture type, number ofaperture and surface ornamentation that are used in delimitation of various taxa(Mbagwu et al.,2008). Morphology of pollens have paid crucial role in classification and identification of plants. Pollen morphological feature have been used by Taxonomist to recognize flora in order to arrange taxa in proper taxonomic rank. (Bahadur et al., 2018). Pollens studies are also helpful in evolutionary and phylogenetic studies of plants (Khan et al., 2017). Pollen attributes have been utilized to produce possible evidence of relationship in various group of Angiospermic plants (Mbagwu et al., 2008).

Morphology of pollen have paid crucial role in classification and identification of plants. Pollen morphological features have been used by taxonomist, recognized in flora in order to arrange taxa in proper taxonomic rank (Ahmad et al., 2020; Kayani et al., 2019; Khan et al., 2021; Raza et al., 2020). These studies are helpful to detect the effect of climate change on characteristics of pollens in some selected species among various regions. Morpho palynological research is one of the significant tool used by modern taxonomists to distinguish closely related species (Ahmad et al., 2018; Bano et al., 2012; Bano et al., 2020). The morphological diversity in pollen grains and simple methods of handling them, make Palynological studies a valuable taxonomic tool. SEM Studies of pollen exine, in particular, have provided useful information. Basic palynology deals with pollen and spore morphology, the physical and chemical properties of pollen wall, as well as the correlation between palynology, cytology and taxonomy etc (Meo and Khan, 2014). According to Kailas et al., (2017), size aperture structure surface, polarity, shape, symmetry, pollen ornamentation is used to differentiate the taxonomic co-relations. Morphology of pollen is very dominant for correct recognition of different plant species at generic and specie level (Arora and Modi, 2008).

Morphology of pollen is of massive importance for the interpretation and documentation of relationship among different species at several different taxonomic levels (Khan et al., 2018). Palynologist investigated the significance of palynological features in different group of plants from time to time and inaugurate it highly effective in the process of identification of plant species (Ashfaq et al., 2020; Jamil Noor, Ahmad, Ashraf, Zafar, & Sultana, 2016; Khan et al., 2018; Mir et al., 2019; Noor, Ahmad, Zafar, & Ashraf, 2017). Recently, the most requisite approach for micromorphological studies of pollen is scanning electron microscopy. The study of pollens through SEM is consequential due to its high resolving power (Khan et al., 2018; Ullah, Zaman, et al., 2019; Ullah et al., 2021; Ullah et al., 2021; ur Rahman et al., 2019). For quantitative examination SEM is a powerful technique which explainedmorphological parameters such as sculpturing in depth, which could not be explained through typical light microscopy (Arshad et al., 2019; Rashid et al., 2018). Palynology of medicinally important plants has been carried out in Pakistan which inspected pollen morphology and medicinal properties of these plants (Amina et al., 2020; Naz et al., 2019; Qureshi, Talha, Ahmad, Zafar, & Ashfaq, 2019).

1.9 Study Area

1.9.1 Location and Topography

The deserts of Southern Sindh are situated in southern region of Pakistan located in Tharparker, Umerkot, Mirpurkhas, and Sanghar (Figure 1). It is the largest desert of Pakistan and the only subtropical desert of Asia, bordered with Thar desertof India towards east, Kirthar range towards west, Cholistan desert towards north and towards east extended to Rajasthan desert, while in south towards the Arabian Sea, it submerges into the Rann of Kutch. It stands on 17th position among deserts of world and 9th position among subtropical deserts in terms of area. Overall Thar desertcovers an area of 120,000 square miles, which is mostly situated in India. Topographyof the region is characterized with sand dunes, alluvial plains, and hill outcrops with mostly dry part, the western Marusthali, and a semi-desert area to the east has fewer sand dunes and receives slightly more precipitation. However, it is characterized with diversity of arid lands, delta and valleys of Indus River, Nangerparkar foothills, and salt land of Rann kachh. It is the most densely populated area among all the deserts of world, with 83 persons per square km. It has a population of about 1.2 million people (Yaseen et al., 2015; Khan and Weber, 2006; Khan et al., 2003).

1.9.2 Climate

The climate is very harsh and dry, with very high temperature in summers, low annual rainfall and higher evaporation rate. The warmest months of year were April, May, and June, with average daytime temperatures ranging from 24°C to 41°C.The annual temperature fluctuates from 20°C to 51°C depending on the season. The coldest months are December, January, and February, with temperatures ranging from9°C to 28°C on average. Annual rainfall is very low, ranges from 88 to135 mm. Most of the rainfall occurs in the months of July to August, most favorable months for monsoon rain. Average monsoon rain fall recorded is 125 mm which sometimes fluctuates due to climatic conditions. However, low-intensity winter rainfall is possible in December, January, and February (Yaseen et al., 2015; Cheema et al., 2012).

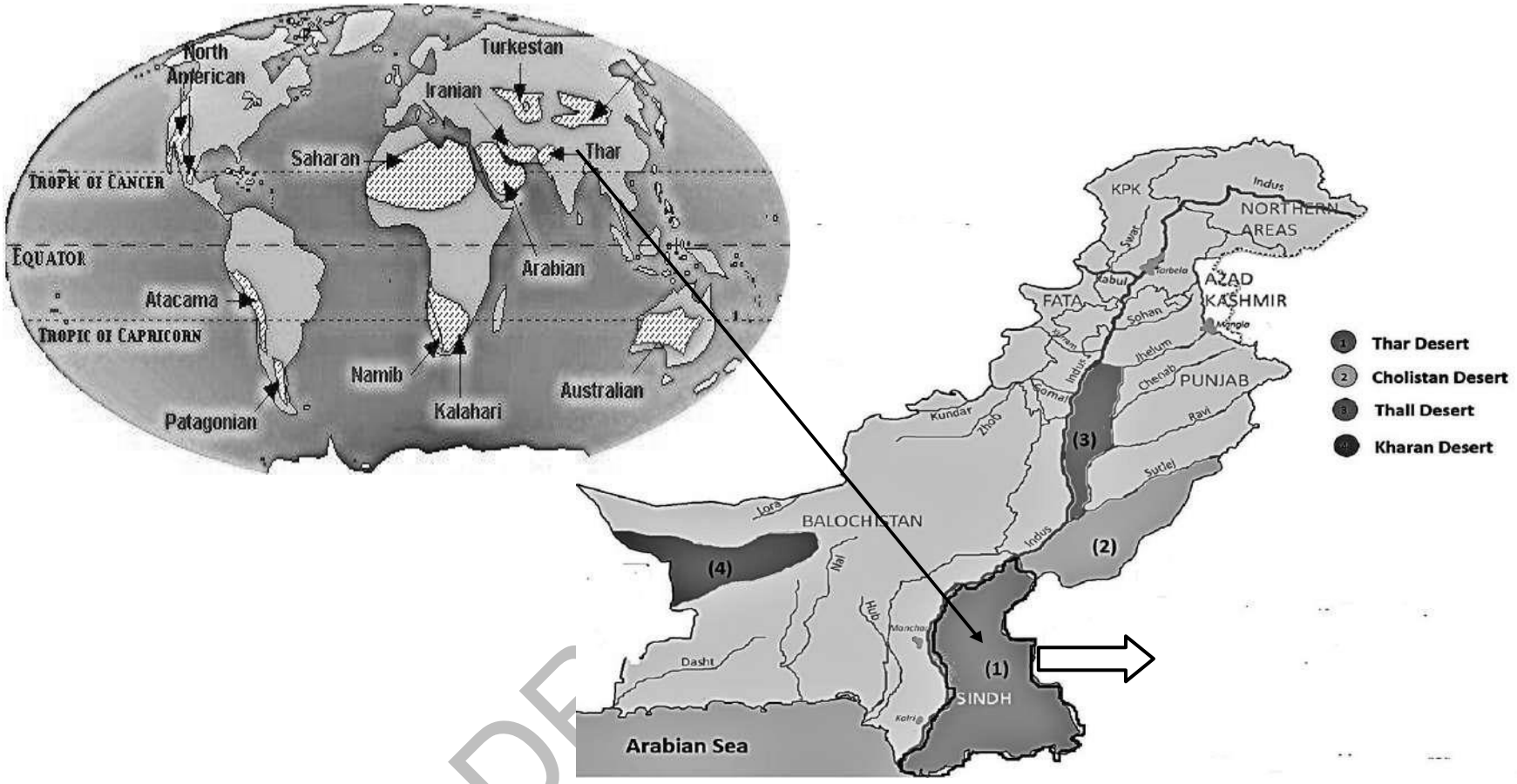


Figure 1 : Map of Study Area (Sindh)

Thar Desert, in Pakistan's Sindh province, is a drought-prone region due to insufficient and irregular rainfall patterns. The current drought has been going on since 2013 and has taken a toll on the local population. Droughts have made water scarce in most places, which has hindered agriculture. Ground water may be found at depths of 50 to 300 feet, with salt concentrations varying. Ponds, dugouts, and tanks filled by monsoon rainfall are the most convenient and readily available source of water (Qureshi and Bhatti, 2005a).

1.9.3 Ethnography

This area has a rich diversified culture, traditions, customs, folklore, dances, and music due to its different population of religions, sects, and castes. The country is divided in two religious groups, with Muslims representing majority and Hindus being in minority. Sindhi, Dhatki, and Gujrati are the most common languages spoken in the deserts of Southern Sindh, whereas Urdu is an uncommon spoken language. Southern Sindh's desert is one of the world's most densely inhabited deserts, with agriculture and animal husbandry being the primary professions of its residents. Agriculture is unreliable in this region since at least one-third of crops fail following the wet season. Due to the tough farming circumstances, animal husbandry has become popular. Both maternal and infant mortality rate are high due to a lack of sufficient health-care facilities. Almost all ethnic groups utilize herbal remedies to treat a variety of ailments, and these communities have a wealth of traditional knowledge about how to use medicinal plants (Qureshi and Bhatti, 2005). Southern Sindh's deserts are home to a diverse range of civilizations and customs. In this desert,a vibrant, tradition-rich civilization reigns supreme. Folk music and poetry are quite popular among the locals. Rajhestani, Sindhi, and Gujrati are the most common. Thariis regarded as the most popular, remarkable, and unusual musician in the world of music. Expert Thari singers, also known as faqirs, are asked to perform at numerous carnivals and traditional activities. Chakar rand, Mitco, Dandan, and Rasooro are the most popular folk dances. Both Muslims and Hindus make up the two ethnic groupings in virtually all of Sindh's desert areas, and they are inextricably linked regardless of religious beliefs (Nasim and Pirzado, 2007).

1.9.4 Plant Diversity

Because of the varied habitats and ecosystems, the flora, human culture, and animal life in this desert region are highly diverse in comparison to other deserts across the world. The thorn scrub forest of the Northwestern United States develops insmall groups that are more or less openly scattered among the dry region of native flora. Perennial herbs and drought-resistant thorny bushes predominate in the majorityof the regions. Droughts, catastrophes, and irregular rainfalls have severely harmed plant biodiversity in Sindh's deserts over the previous century, due to global warming and fast climate change. *Acacia Senegal, Prosopis cineraria, Tecomella undulata, Commiphora wightii, Euphorbia tirucalli, Pedalium murex, Moringa concanensis, Cistanche tubulosa, Acacia jacquemontii, Senna occidentalis* and others are among the most significant medicinal species. Each desert support habitat and landform of distinct flora and fauna, each with its own niche that is unique to the Thar. Plant species that are economically significant have become endangered (*Commiphorawightii*, *Tecomella undulata*, *Prosopis cineraria, Acacia nilotica, Tamarix aphylla, Cenchrus biflorus*, and *Calligonum polygonoides* are among the most significantfloral species (Khan and Frost, 2001).

1.9.5 Population

Thar Desert and Achro deserts in southern Sindh support majority of livestock and human population. The main population region is made up of small nomads who are distributed based on their requirements and rainfall patterns. Sindhi is the most frequently spoken language, however mother tongues differ by ethnic group. Thari people who reside in the deserts of Southern Sindh, and raising livestock is their primary source of income. Agriculture, which fails due to a water scarcity, irrigated land and farming, which results in land overgrazing, are the two main occupations of its inhabitants. Despite the fact that the area is frequently under drought, residents have nothing else to do. Because there is a severe shortage of education in the region, they rely on these vocations (Yaseen et al., 2019; Qureshi and Bhatti, 2008).

1.9.6 Health and Education

In rural Sindh, the status of education is worrisome. Tharparkar is one of the most underserved districts in Southern Sindh in terms of providing education to rural children. There is a shortage of educational facilities, as well as significant gender discrepancies. For a population of 0.235 million children (4-9 years), there are only 3676 primary schools, and disturbingly, more than half of the youngsters are out of school. Girls have considerably fewer educational opportunities than boys. There are only 447 primary schools for females in the district, out of 3676 total primary schools. As a result, most females are forced to stay at home, and if some do manage to get to the boys' schools, their chances of dropping out rise. Tharparkar has a 21 percent dropout rate (SEMIS 2003-2004). The training process is insufficient since there are limited possibilities for training and teachers are underqualified (Nasim and Pirzado, 2007). According to current statistics, the literacy rate in most of the regions, particularly Tharparkar, is less than 17%. According to Ailan (2015), the female literacy rate among Thari people is only 7%. Poverty, a lack of basic educational facilities, and cultural restrictions have all been identified as contributing causes.

People in Sindh's Southern Desert used to experience a variety of healthissues, including waterborne illnesses, poor health facilities, hunger, and a lack of basic infrastructure. Apart from that, poverty, population expansion, a shortage of safe drinking water, unemployment, and a high rate of illiteracy have engulfedTharparkar. In most regions of Southern Sindh's deserts, there are no basic health services. Health clinics with limited services are only accessible in district headquarters, making access to such services impossible for rural populations livingin remote areas without adequate roads and transportation. Because doctors and nurses are not readily available in communities, lower-level employees such as health technicians do specialty jobs, which is another major cause of child death. As a result of their continual work in the field, majority of women are in poor physical shape, which creates mental and physical difficulties. Due to illiteracy and a lack of basic health care, In many parts of the world, the practice of a medical assessment during pregnancy is relatively uncommon. Many labor concerns are tackled by unskilled and uninformed technicians at the local level, resulting in perinatal fatalities (Malik,2018).

Plate 4: Beautiful Panoramic views of study area

A) Mithi B) Bhodasar C) Umarkot
D) Islamkot E) Umarkot Fort F) Naon kot Fort

Plate 5: Plant diversity Panoramic view

A) Karoonjhar B) Qasbo C) Bhodhesar
D) Dewasi Village E) Nangerparker Dam F) Bhalwa Hills

Plate 6: Religious places in the Southern Desert

A) Daromall temple B) Jain temple C) Goro Nak temple
D) Gori Temple in Bhawla E) Nagar hills F) Nagrar park in Temple

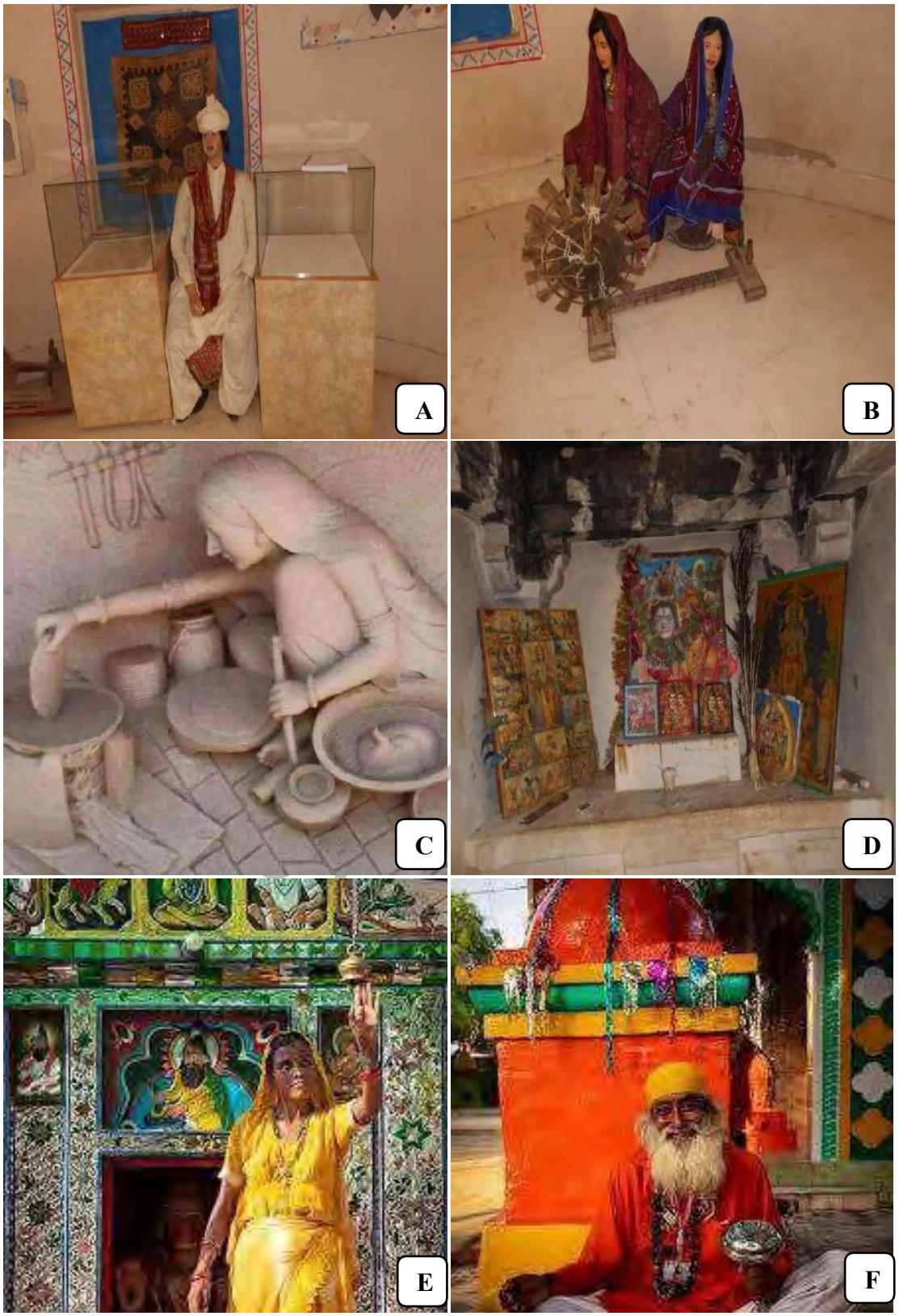


Plate 7: Diversity of Cultural heritage in Desert of Southern Sindh

A) Umer B) Marvi C) Qambar
D) Gori Mandar E) Baba je Temple F) Goro Nanak

Plate 8: Human Living style in the Desert of Southern Sindh

A) Village Amrio
B) Village of Faqeer Muqeem Khunbar
C) Village Khano Bheel
D) Village Jumo Soomro
E) Nohto village
F) Village Ruplo Koli

Plate 9: Human Population in the Desert of Southern Sindh
A) Thukar Koah B) Acharo Thar C) Marvi Jo Koah
D) Diversity of crops E) Village Nisar Khellro F) Source of income

1.10 Medicinal Plants of Deserts of Sindh

Overall, the deserts of southern Sindh are distinct landscapes with a diverse range of xerophytes and indigenous vegetation. These desert habitats provide excellent pastureland that may be utilized to raise cattle. Furthermore, these ecosystems provide fuel, shelter, nourishment, and medicine to the people who live there. However, because to high stress from grazers and browsers, increased land use for agriculture, fuel, lumber and range resource collectors for diverse uses, these unique ecosystems are losing their potential. For the long-term development of the landscape in the area, To analyze the patterns of distribution of the flora, the maintenance of essential variety of range and forage grasses, legumes, and other forbs, and grazing system rotation, rigorous studies on vegetation composition and geographic information system studies are necessary. Except for Nangerparker, most of the regions have little vegetation. Perennial herbs and drought-resistant thorny bushes predominate in the majority of the regions. *Commiphora whitii, Euphorbia tirucalli, Tecomella undulata, Pedalium murex, Moringa concanensis, Cistanche tubulosa, Acacia jaquemonti, Senna occidentalis* and others are among the most significant plant species. Economically important plant species have become vulnerable or endangered (*Commiphora wightii* and *Tecomella undulata*). Native species of area have ethnoecological requirements and must reproduce in order to survive (Khan, 1996).

A variety of ethnomedicinal documentation projects have been carried out in diverse geographical locations in Sindh's deserts since 2007 (Saand et al., 2019; Yaseen et al., 2019; Yaseen et al., 2015; Memon et al., 2010; Qureshi et al., 2010; Qureshi and Bhatti, 2009; Memon et al., 2008; Qureshi and Bhatti, 2008; Panhwar & Abra, 2007). Temperatures, biotic zones, and topographical locations vary widely in Sindh, all of which are rich in MPs (Hussain et al., 2010), and desert areas of Sindhare reported to be undiscovered in terms of ethnobotanical medicinal plant surveys. Furthermore, deforestation, famines, lengthy droughts, traditional healers relocation, and historical ignorance related to ethnomedicinal recording have all contributed to the province's indigenous knowledge being severely depleted (Kadir et al., 2012, Kadir et al., 2013). As a result, ethnomedicinal plant knowledge in the Thar Desert is at jeopardy (Sindh).

1.11 Justification of the Present project

Many ethnobotanical research has been conducted in Pakistan's northern hilly areas and Punjab plains, but the medicinal plants and their use patterns in the deserts have been overlooked for a variety of reasons. Some of the primary causes are a lack of knowledge among the local population, a lack of amenities for foreign employees, and the lack of research and academic institutes in deserts. Only a few research on Cholistan and the Thal desert have been undertaken, according to a review of the literature (Khan, 2009; Chaudhari et al., 2013; Ahmed et al., 2014, b; Shaheen et al., 2014; Malik et al., 2015). Besides, some records are also found from Nara desert (Qureshi and Bhatti, 2008). However, the majority of above reporetd studies from deserts in Pakistan presents only checklist of plant species without any focus on possible ways of herbal drug drug development and their sustinabale utlization approach of medicinal plant species. In the recent, ethnobotanical studies may be condcuted with comprehensive information related to ways of herbal drugs development with sustainable utlization.

Southern Sindh's deserts are unique among Pakistan's deserts because of their geographical position. Several locations in Southern Sindh provide unique habitats for rare and critically essential medicinal plant species. In the desert, different medicinal plants thrive in different habitats and landforms, each with its own niche (Khan et al., 2003). Traditional plant-based cuisines are firmly established among indigenous desert people, particularly in Sindh's southern area. Indigenous populations in most rural regions rely on herbal medicines made from local plant species for their basic treatment. The deserts of Southern Sindh include a diverse range of medicinal plants that serve as a source of herbal remedies, rituals, cultural activities, food, forage, and shelter for numerous nomadic groups. Being close to nature, the people of deserts have rich diversity of ethnobotanical knowledge about the precious medicinal plants species whose use pattern is always culturally transferred from generation after generation. On other hand, the desert communities of Southern Sindh possess rich culture of preparation of veterinary medicine from important medicinal plant species culturally associated with cattle populations. Important plant species are *Commiphora wightii*, *Abrus precatorius*, *Euphoribia tirucalli*, *Blepharis scindica* and *Moringaconcanensis*. These are very well-known important plants used in herbal drugs for

human population as well as cattle. Various plant species are considered as integral component of indigenous culture of deserts in Southern Sindh and knowledge associated with medicinal plants species is transferred through oral dialect from generation after generation. To best of our knowledge and comprehensive literature review, no detailed study has been conducted on the Ethnobotany medicinal plants and their possible way of sustainable utilization in the deserts of Southern Sindh with special emphasis on herbal recipes for herbal drugs development. There are many medicinal plant species commonly used against human disorders treatment as well as veterinary diseases in the rural population of Deserts. The ethnobotany of medicinal plants for prospective long-term use as herbal medications may open up new possibilities for the production of herbal drugs and the preservation of valuable indigenous knowledge on medicinal plants in deserts of Southern Sindh.

It is evident that it is essential and crucial to study, learn, and evaluate the traditional and indigenous systems prevailing among the livestock rearing folk without being biased and to promote, motivate and integrate the beneficial effects of such practices. However, in order to maintain the integrity of this system and to promote community based traditional practice oriented sustainable livestock production system, it is crucial that the traditional animal health care practices are assured and integrated with the with research base of modern livestock health care practices. Knowledge pertaining to ethnoveterinary practices is consolidated in many parts as a large proportion of the world's population still rely on livestock rearing as a source of income and food and employ plants and their corresponding preparations to treat animal ailment conditions.

The present study concentrated on livestock farmers of deserted rangeland and the indigenous and traditional animal management and healthcare practices followed by them in animal rearing. The study of ethnoveterinary medicine plays an inevitable role in livestock development and which also need to be supported by the experts in related fields. Steps to initiate various activities of documenting, validating and also ruling out the potential effectiveness of these traditional animal health care practices by documenting the botanical resources through effective studies have to be taken.

Various scientists and researchers have opined that the knowledge of ethnomedicine as transmitted over generations, if used positively, would act as a pool

of resourceful information which would be an asset for sustainable livestock health management systems. Human ethnomedicine and ethnoveterinary medicines were complementary and ethnoveterinary medicine remains an ethno scientific resource. However, this project has to be explored more which is inevitable for the sustainable and stable economic development of the poor indigenous communities in deserts who have limited or no access to contemporary and modern medical and management advice and services. There exists a need for avoiding the misuse of ethnoveterinary knowledge and indigenous practices. The identification of appropriate interventions of the indigenous practices and ethnoveterinary practices is a great challenge for researcher's as it demands exploration and interaction with local communities, NGOs,governments for mainstreaming indigenous/traditional knowledge available with them.

The initiation of the idea of the present study was from detailed analysis and perusal of literatures, reviews, associated primary and secondary data available. The objectives were planned based on the above analysis was primarily designed to identify the gaps in this research, which was needed to accomplish in this project. Accordingly, the objectives based in research study, methodology was fixed ensuring that it cater to the needs of addressing those identified gaps and issues pertaining to the ethnoveterinary practices. The objectives thus fixed focused on the identification and evaluation of such ethnoveterinary, and indigenous practices of medicinal plants followed by these livestock farmers in Southern desert was designed in such a way that the objectives should be capable of bringing out solution to the assessments regarding the level of adoption of the ethnoveterinary herbal medicine and indigenousveterinary practices with special emphasis to the degree of rationality in these practices.

The use of natural products to treat diseases is not only restricted to humans but extends to treat various disorders in animal species as well. In Southern deserts of Sindh, veterinary public health is not integrated into the mainstream of public health services. There are no formal mechanisms within government public health services through which veterinary skills and resources can be effectively harnessed to bear upon community health. Given the importance of EVM to low-income populations, particularly in desert regions, recording, documenting, and disseminating the use of

plant species for animal disorders is of great importance in this area. One of the most distinguishing features of desert is its biodiversity.

Thus, inventories or systematic studies addressing EVM should be promoted for three important reasons: (a) they can generate useful information needed to develop livestock healing practices and methods that are suited to the local environment; (b) EVM could be a key veterinary resource promoting the use of phyto-therapeutics, including plants and plant based herbal drug development, and (c) EVM can contribute to biodiversity conservation.

Application of medicinal plants as a source of drugs in treating human and animal diseases has been a traditional practice. Ethnoveterinary medicine has become an elemental factor of primary health care, especially for marginalized and poor communities living in remote rural areas. Ethnoveterinary medicine often offers less expensive options than conventional medicines, products are locally available and more easily accessible, and are generally less toxic. However, knowledge of ethnoveterinary practices is declining due to inadequate documentation and verbal passage of plant heritage verbally. Traditional veterinary practices can offer treatments that represent accessible and affordable alternatives for the control ofdiseases of nonhuman animals; however, these practices have yet to be studied,evidencing the need for investigations into the traditional use of natural therapeutic herbal products, as well as their potential efficacy.

The present study was aimed to record the use of medicinally important plants in the Southern Desert in Sindh used in the treating of animal and human diseases. The primary focus of current study is to provide a significant traditional knowledge on wild medicines used for ethnoveterinary purposes in the rural communities in desert. The focus of this project is to document this knowledge before it is lost as it is commonly passed down orally from generation to generation, as is the case with many traditional medicine systems around the world. It was stated that this knowledge could also be used practically in animal management (livestock), to improve their health and the economy.

1.12 Aims of the present Project

The present study was confined to the ethnobotanical exploration of important medicinal plant species used to treat livestock disorders commonly used as source of herbal medicine in the deserts of Southern Sindh-Pakistan. The specific aims ofpresent study were:

- To explore the diversity of important plant species commonly used the rural communities int the deserts of Southern Sindh.
- To documents the sustainable ethnobotanical uses of medicinal plant species along with cultural recipes used for the treatment of veterinary disorders of livestock.
- Documentation of ethnoveterinary resources promoting the use of precious medicinal plants as herbal drugs.
- To document the medicinal uses of important plant used as herbal drugs for the treatment of human rural populations.
- To analyze the ethnomedicinal data on important plant species using qualitative and quantitative techniques for sustainable utilization of precious medicinal species in the deserts of Southern Sindh.
- Microscopic characterization of selected medicinal plants using Pollen morphology for correct identification.

CHAPTER: 2

Material and Methods

This project was confined to ethnobotanical exploration of medicinal plant uses for sustainable utilization of herbal drugs in deserts of Southern Sindh, Pakistan. The project was basically designed to explore the important medicinal plant species using ethnobotanical and palynological approaches. The present study was comprised of five major steps including a) field photography, b) Plant collection, c)ethnobotanical data collection, d) Data analysis using qualitative and quantitative approaches, and e) Pollen morphological studies.

The study was conducted during three different seasons during 2017 to in 2021 with multiple field surveys depending upon seasons of plant species. During field surveys the digital photography was carried using camera. While during field surveys, the plant species were collected for correct identification and ethnobotanical data documentation. The plant collection step involved plant specimen collection, field notes on plant species, identification, pressing of plant specimens, allotment of voucher specimens and deposited in the Herbarium. The ethnobotanical data including treated diseases, plant part used, mode of utilization, indigenous recipes and doses was documented using open ended, semi structured questionnaires and group discussion. The ethnobotanical data collection involved confirmation of IP and PIC, free listing of plant species, Plant interviews, group discussion, field walks along withconsensus of informants, and compilation of results. The data collection was composed of two components that demographic part and plant part. The demographic part of questionnaire comprises information on age, gender, education, and experienceof uses of plant species. Plant part of questionnaire contain detailed information on names of plant (Local and Botanical), plant used part, mode of utilization, disease treatment and localities of plant species. Data on the plant parts used, method of preparation, dosage, route of administration, treatment of the disease, conservation status, cultivation procedure and acquisition/transfer of indigenous information were gathered from each informant. Using qualitative and quantitative methods, the obtained data was analyzed.

2.1 Informant Consents and Property Rights

The present study was carried out from Spring 2017 to fall 2020. Residents in the research region provided documentation for the study. Prior to conducting field surveys, a proper ethical permission was obtained from the university ethical committee, and local administration was notified. Residents and research participants were given a thorough explanation of intellectual property rights. Before interviewing any participant, the goals and objectives were explained in detail, and the participation of each person was appreciated at each stage.

2.2 Field Surveys

Local people and traditional health practitioners (THPs) were questioned during field surveys using semi structured interviews, group discussions, and questionnaires. Informants were chosen at random as well as specifically (only when traditional health practitioners were interviewed). The informants were asked to provide information on the plants that are widely used to treat certain illnesses. Free listing methods, semi-structured questions, open-ended interviews, and group discussion were utilized to capture the data on medicinal applications, plant components used, and manner of usage. Group talks were held at designated locationswhere members of the same group congregated for social occasions. Plants were gathered, digital photography was done, and plant samples were taken to the informants for data collection in the majority of cases. The traditional medical practitioners travelled along to the location where the medicinal plant was growing, provided its local name, and explained ethnomedicinal knowledge of the medicinal plant species during the guided field walk. The medical species were then gathered, with all pertinent information about the medicinal plant species being recorded.

The purpose of the questionnaire was to collect information about the plant-based treatments utilized by the inhabitants of the Deserts of Southern Sindh. The questionnaire was split into two sections. The first section dealt with the informants' demographic information, including their name, gender, age, education, employment, location, and expertise with plant-based recipes. The second section covered traditional plant information, such as common name, habitat, plant part utilized,

disease treated, manner of administration and use, dose, plant preference, and particular disease treated.

Questionnaire used in Ethnoveterinary and Ethnobotanical Medicinal plants diversity in Deserts of Sindh-Pakistan

(A) Informant's Details

Name_____
Gender_____
Age_____
Occupation_____
Education_____
Mother language_____
Location/Residence_____
Description of Locality_____
Experience of using MPs by THPs_____

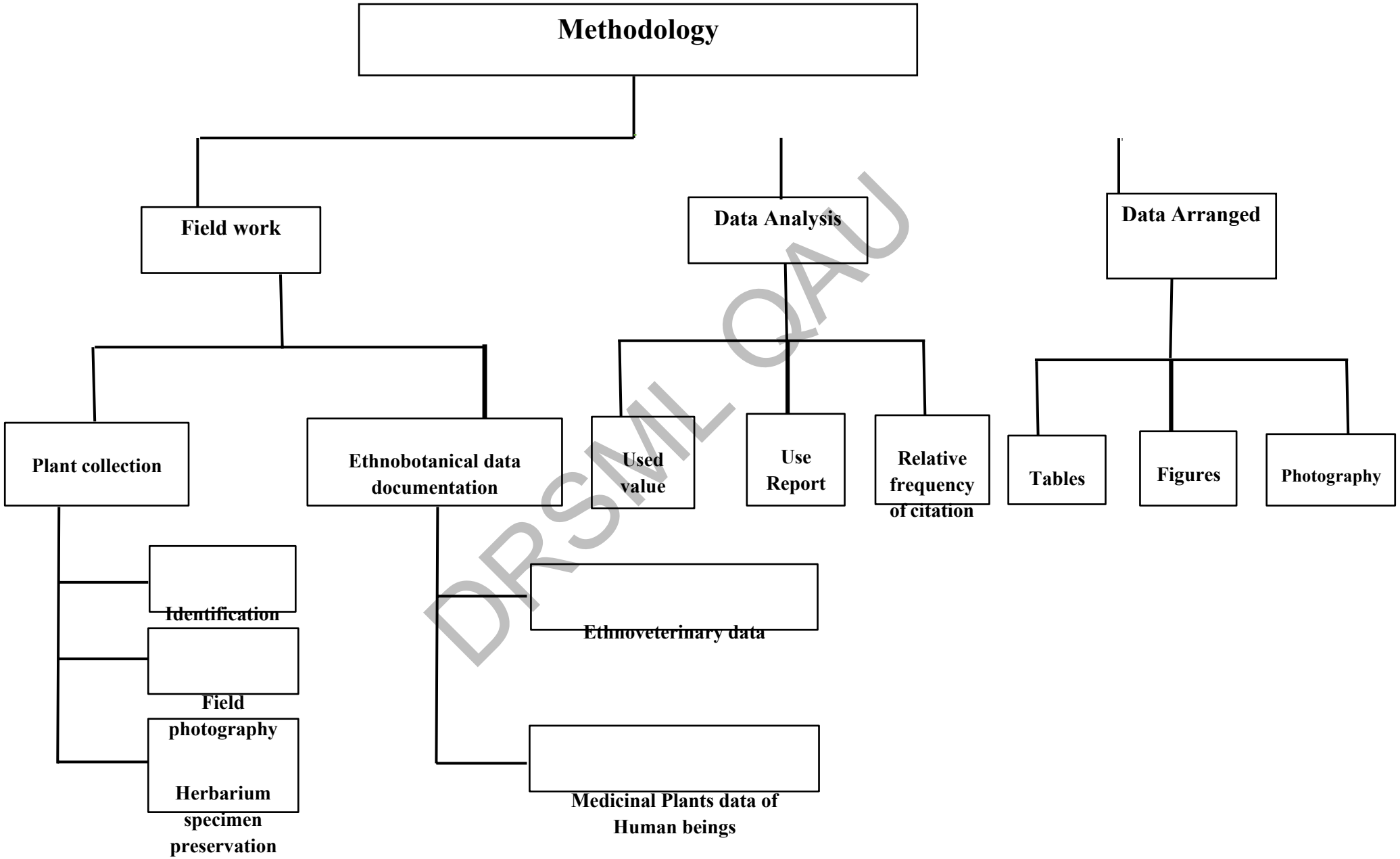
(B) Data of MPs for Ethnoveterinary Practices

Plant (Local name) _____
Habit (Tree/ Herb/ Shrub/Climber)_____
Habitat_____
Plant part used (Leaf, Stem, Root, Flower, Seed, Whole plant, Others)_____
Plant Value (Medicinal/Food/Fuel wood)/Miscellaneous_____
Locality_____
Animal disease(s) treated in (Cow, Buffalo, Goat, Camel, Sheep, Dog)_____
Method of crude drug preparation_____
Dosage_____
Market value of Plant _____
Plant identified as (Botanical Name and Family)_____

(C) Data of MPs for treatment of Human Diseases

Plant (Local name) _____
Habit (Tree/ Herb/ Shrub/Climber) _____
Habitat_____
Plant part used (Leaf, Stem, Root, Flower, Seed, Whole plant, Others)_____
Plant Value (Medicinal/Food/Fuel wood)/Miscellaneous_____
Locality_____
Human disorder treated_____
Mode of administration (Decoction, Paste, Infusion, Raw, Juice, Others)_____
Dosage (Oral and Topical)_____
Market value of Plant _____
Plant identified as (Botanical Name and Family)_____

Signature of Informant


Methodology
Field work
Data Analysis
Data Arranged
Plant collection
Ethnobotanical data documentation
Used value
Use Report
Relative frequency of citation
Tables
Figures
Photography
Identification
Field photography
Herbarium specimen preservation
Ethnoveterinary data
Medicinal Plants data of Human beings

2.3 Plant collection

The proposed project was confined to ethnobotanical exploration of medicinal plant uses for sustainable utilization of herbal drugs in deserts of Southern Sindh, Pakistan (Map 1). A number of trips to the fields were carried out during various blossoming seasons in the years 2017-2020. Plants with floral parts were collected, pressed, dried and placed in blotting papers and newspapers. Field data was recorded in the field notebook regarding date of collection, field number, locality, habit, habitat, phytography, flower color and flowering period. However, we requested the informants' assistance in collecting field specimens of any unfamiliar species widely employed in herbal preparations. Many local informants assisted in the gathering and photographing of plant species in the field during the interviews. A digital camera (model-Nikon S-444/China) was used to picture the reported plant species. During thefieldwork, the plant sites were visited at various times of the year to capture picturesof the plants in bloom.

2.4 Plant Identification

Accessible literature was utilized to identify plant samples. Specimens were further confirmed comparing them with already documented plant samples or specimens in the Herbarium of Pakistan (ISL). After correct identification, preserved specimens were placed in Herbarium of Pakistan (ISL) to expedite and facilitate the future references. The Flora of Pakistan, as well as taxonomists and herbaria at the Quaid-i-Azam University in Islamabad, were used to identify reported plant species (ISL). The proper taxonomic names and families were confirmed using several sources, including the Royal Botanic Garden Kew's Plants of World Online (POWO) database and the Kew Botanical Gardens' medicinal plant naming service (http://mpns.kew.org/mpns-portal) and the plant list (www.tpl.org).

2.5 Plant Preservation

The plants were taken to the Botanical Garden Quad-i-Azam University in Islamabad-Pakistan for poisoning. For preservation, the dried plant specimens were dipped in a solution containing 10 g of Mercuric chloride and 1 litter of ethyl alcohol. The plant specimens were immersed, using forceps, in the solution for about 15-20

seconds depending upon the thickness of the specimen. After poisoning, using German glue, plants were placed on herbarium sheets of standard size (42cm ×28cm), accompanied by the fixing of labels on the right corner of the herbariumsheets. All the field data was shifted on herbarium labels pasted on the sheet following the previously published protocol of Ahmad et al. (2018). The tags were filled with all appropriate details on the plant species, including the name of the botanical name identifier, the family, the synonyms, the vernacular name, the location, the name of the collector, the date of collection, the specimen number of the voucher, the number of the accession and the altitude. The Herbarium of Pakistan provided all the materials necessary for mounting (ISL).

2.6 Data Analysis

The documented data was analyzed using ethnobotanical indices including Frequency of Citation (FC), Relative Frequency of Citation (RFC), Use Value (UV), and UR (Use Report).

2.6.1 Frequency of Citation (FC) and Relative Frequency Citation (RFC)

The frequency of citation refers to the number of informants who mention the use of the species (FC). The relative frequency of citation was calculated based on local popularity among study participants to estimate the relative relevance of reported species. It is determined by dividing the total number of informants in the study by the number of study participants questioned for a species. It is calculated using following formula:

$$RFC = FC / N \quad \text{.....(i)}$$

Where FC (Frequency of Citation) stands for the number of informants mentioning the use of the species and N is the total number of informants (Vitalini et al., 2013).

2.6.2 Use value (UV)

Use value was applied to find all the probable medicinal uses of a plant species. This quantitative index indicates the relative importance of plants on the basis

of their traditional use identified by the local people. It is calculated using the formula below:

$$UV = \Sigma U/n \text{..... (ii)}$$

Where, "U" represents the number of participants reporting all the probable medicinal uses of a plant and N is the total number informant participating in the study (Bibi et al., 2014).

2.6.3 Use Reports (UR)

The number of medicinal uses of a plant was used to determine UR. A single use-report (UR) for a plant was indicated every time, if an informant cited it for a specific disorder. If an informant reported a plant for several disorders in the same category, it was still considered a single usage report. For multiple uses, two or more UR values were recorded (Ong et al., 2018).

2.7 Palynological studies

Pollen was separated from anthers for pollen micromorphological studies. Glycerin jelly was prepared according to modified techniques of (Meo, 2005). Protocol established by (Edrtman, 1952) was followed to acetolyzed materials on slides were crushed for a short time to soften up the anthers, rrelease the pollen grains from anthers, remove additional organic material on pollen surfaces, and finallystained the pollen with glycerin jelly, for LM photography at 40X with Nickon fx-35 microscope equipped with camera model:1-5 C-ME1. Quantitative measurementswere measured using an eyepiece (ocular;10X) with the scale that includes polar diameter (PD), equatorial diameter (ED), aperture dimension, exine thickness and spine length of pollen grains were determined in 10 grains randomly chosen from each sample. The arithmetic mean, standard error of the mean (SD) of these measurements were calculated by using SPSS (16.0) software.

Anthers were taken from the selected individual species of each bee foraged plants. Using methods of acetolysis pollen were prepared for SEM (Erdtman, 1969). The flowers' anthers were placed on a slide and crushed with a metal rod, 2 drops of acetic acid, double-sided tape, and gold-palladium spray. For pollen staining, a drop of glycerin jelly was added, followed by tissue paper cleaning (Meo & Khan, 2005).

With a Jeol JSM-T200 SEM, a micrograph of the detected pollen was taken, and exine sculpturing was also noticed.

Percentages of pollen fertility and sterility were calculated based on staining. The number of pollen grains stained and unstained were counted. Pollen that was ffully stained were considered fertile, whereas pollen that was unstained and deformed were regarded sterile. The formula proposed by Majeed et al. was used to calculate the fertility and sterility percentages of pollen (2020)

Fertility = F/F + S × 100… .....(i)

Sterility = S/S + F × 100 .....(ii)

Where 'F' and 'S' represented no of fertile and sterile pollen respectively.

2.7.1 Statistical analysis

The mean, maximum, minimum, and standard error were computed using IBM SPS 16.00 statistical software. For statistical examination of the mean (minimum-maximum) SE, nearly ten readings were collected.

Plate 10: Ethnobotanical data documentation

A) Interviews from folk singers B) Local resource persons
C) Interviews from local vendors D) Interviews with shepherds
E) Group discussion in field F) Interviews with plant traders

Plate 11: Plant Collection in the field

A) Umerkot B) Islamkot
C) Tharparker D) Soomra Village Acchro Thar
E) Sandro Village Sanghar F) Nagarparkar

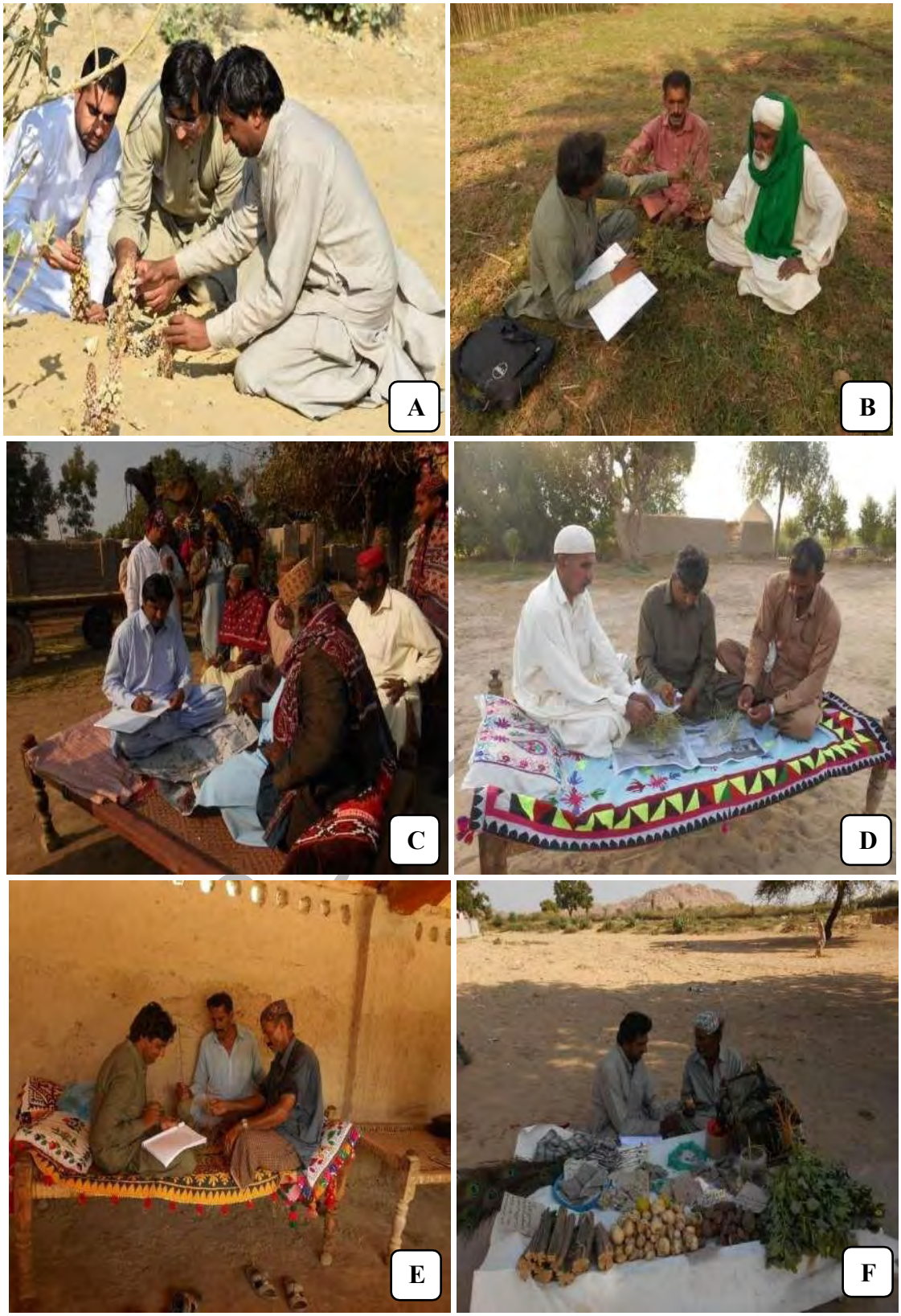


Plate 12: Field Plant Identification & Documentation

A) Field identification
B) Interviews with THPs in field
C) Interviews with THPs in local market
D) Documentation in Nohoto Village
E) Local Expert in Tali
F) Local herbal seller in Nangerparker

Plate 13: Herbal recipes documentation about veterinary disorders

A) Home based preparation recipes B) Administration of Recipes

C) Local treatment methods D) Recipes give to Goat for treatment

E) Goat delivery conditions F) Urinary disorder of Goat

Plate 14: Laboratory experimentation work (a) Microscopic studies of specimens (b) Microscopic slides preparations of pollen

CHAPTER: 3

Results and Discussion

The present study was confined to document the ethnobotanical values of medicinal plants commonly used as herbal medicine in the deserts of Southern region of Sindh Pakistan. Overall, the aims of the present project were: exploration of the diversity of important plant species commonly used in rural communities in thedeserts of Southern Sindh; documentation of the sustainable ethnobotanical uses of medicinal plant species along with cultural recipes used for the treatment of veterinarydisorders of livestock; documentation of the medicinal uses of important plants used as herbal drugs for the treatment of human rural populations, and analyses of data through ethnobotanical qualitative and quantitative techniques for sustainableutilization of precious medicinal plant species in the deserts of Southern Sindh. The data was collected through field photography of plant species, plant sampling, ethnobotanical interviews including open ended questionnaires, semi structured interviews and group discussion with local people, experts, THPs and herbal sellers. The collected data includes the checklist of important medicinal plant species (botanical name, family, lifeform, and their existing localities). Medicinal uses ofeach species include the information on plant part used, mode of utilization, mode of administration, diseases treated and precise indigenous methods of preparation of herbal recipes applications.

These results are comprised of 124 important medicinal plant species belonging to diverse families, organized into three sections. First section highlights the floristic checklist in the form of Table 4 that includes taxonomic name, family, life form, voucher specimen number and include localities; second section include the diversity of medicinal plant species used for veterinary disorders while the third section deals with the traditional medicinal uses of medicinal plant species for the treatment of Human diseases. The results compiled into three sections are:

Section I: Checklist of precious Medicinal plant species used in the Deserts of Southern Sindh.

Section II: Ethnobotany of Medicinal plant species used for the treatment of Veterinary Disorders of Livestock.

Section III: Ethnobotany of Medicinal plant species used in Treatment of Human Diseases.

Section IV: Section of Pollen Morphology

Section I: Checklist of precious Medicinal plant species used the Deserts of Southern Sindh.

Table 4: Checklist of Medicinal plant Species commonly Used in the Deserts of Southern Sindh

S. No	Taxonomic name of the Plant	Family	Voucher Specimen no.	Local name	Life form	Localities in study area
1.	*Acacia modesta* Wall.	Mimosaceae	AK-02	Jhangli Koon	Tree	Khapro
2.	*Acacia nilotica* (L.) Delile	Mimosaceae	AK-09	Babur	Tree	Jan Mandar
3.	*Acacia senegal* (L.) Willd.	Mimosaceae	AK-07	Babari	Tree	Nabi Sar Road
4.	*Achyranthes aspera* L.	Amaranthaceae	AK-40	Ubat kandi	Herb	Sardharo Jabbal
5.	*Aerva javanica* (Burm.f.) Juss. ex Schult.	Amaranthaceae	AK-01	Boah	Herb	Tando Jan Muhammad
6.	*Alhagi maurorum* auct. non Medik.	Fabaceae	AK-05	Kandeero	Herb	Bhalwa
7.	*Amaranthus viridis* L.	Amaranthaceae	AK-08	Chhaloai	Herb	Bhodoser
8.	*Anticharis glandulosa* Asch.	Scrophulariaceae	AK-12	Gamesh	Herb	Islamkot road
9.	*Arnebia decumbens* (Vent.) Coss. & Kralik	Boraginaceae	AK-18	Pinki bot	Herb	Naie kot
10.	*Arthrocnemum macrostachyum* (Moric.) K. Koch	Chenopodiaceae	AK-04	Larron	Shrub	Faqeer Muhammad Bux
11.	*Asphodelus tenuifolius* Cav.	Asphodelaceae	AK-14	Jhagli basri	Herb	Muhammad bux Narejo
12.	*Avena sativa* L.	Poaceae	AK-21	Javi	Herb	Layakharo
13.	*Azadirachta indica* A. Juss.	Meliaceae	AK-32	Num	Tree	Mahesh Kumar Malani
14.	*Barleria prionitis* L.	Acanthaceae	AK-23	Manymor	Herb	Gujarie
15.	*Barleria acanthoides* Vahl.	Acanthaceae	AK-105	Kandari	Herb	Nangar park hill
16.	*Blepharis scindica* Stocks ex T.Anderson	Acanthaceae	AK-19	Asghphan	Herb	Malanhore Vena
17.	*Boerhavia procumbens* Banks ex Roxb.	Nyctaginaceae	AK-25	Naagi wari	Herb	Chellar
18.	*Calligonum polygonoides* L.	Polygonaceae	AK-17	Fog	Shrub	Majathi

19.	*Calotropis gigantea* (L.) Dryand.	Asclepiadaceae	AK-31	Akk	Shrub	Khario Ghulam Shah
20.	*Calotropis procera* (Aiton) Dryand.	Asclepiadaceae	AK-10	AKi	Shrub	Seengaro
21.	*Capparis decidua* (Forssk.) Edgew.	Capparaceae	AK-22	Khaire	Shrub	Sonal Beh
22.	*Capparis spinosa* L.	Capparaceae	AK-27	Galaro	Herb	Bapuhar
23.	*Celosia argentea* L.	Amaranthaceae	AK-24	Salaaro	Herb	Jaindo dars
24.	*Cenchrus biflorus* Roxb. Bhurat	Poaceae	AK-48	Bhuart	Herb	Giryanchho
25.	*Chenopodium album* L.	Chenopodicaeae	AK-112	Jhul	Herb	Village Khetiari
26.	*Chenopodium murale* L.	Chenopodicaeae	AK-80	Jhali	Herb	Bhitaro
27.	*Cistanche tubulosa* (Schenk) Wight	Orobanchaceae	AK-54	Jogjero	Herb	Bhitaro
28.	*Citrullus colocynthis* (L.) Schrad.	Cucurbitaceae	AK-33	Troh	Trailer	Bolhar
29.	*Citrullus lanatus* (Thunb.) Matsum. & Nakai	Cucurbitaceae	AK-50	Thari Tarbooz	Trailer	Sardar Khan mithi Road
30.	*Cleome brachycarpa* (Forssk.) Vahl ex DC.	Cleomaceae	AK-60	Wadi Kandi	Herb	Daro Mill village
31.	*Cleome viscosa* L.	Cleomaceae	AK-39	Khani Boti	Herb	Jhimario
32.	*Coccinia grandis* (L.) Voigt	Cucurbitaceae	AK-62	Sitari wallah	Climber	Naro Goath
33.	*Cocculus hirsutus* (L.) W.Theob.	Menispermaceae	AK-28	Sar parrno	Climber	Jhimario
34.	*Convolvulus arvensis* L.	Convolvulaceae	AK-15	Haran Chapri	Climber	Bolhar
35.	*Convolvulus prostratus* Forssk.	Convolvulaceae	AK-30	Khiranj	Trailer	Goth Ahori
36.	*Corchorus depressus* (L.) Stocks	Tiliaceae	AK-34	Mudari	Herb	Village Khano Bheel
37.	*Cressa cretica* L.	Convolvulaceae	AK-37	Oin	Herb	Qasboo village
38.	*Crotalaria burhia* Benth.	Fabaceae	AK-70	Bohie phali	Herb	Muhammad Soomar
39.	*Crotalaria medicaginea* Lam.	Fabaceae	AK-43	Andari	Herb	Muhammd Bux Arain
40.	*Ctenolepis cerasiformis* (Stocks)	Cucurbitaceae	AK-115	Bari Walh	Climber	Wajhat Mahar village

	C.B.Clarke					
41.	*Cuscuta reflexa* Roxb.	Cuscutaceae	AK-118	Bapari	Climber	Chachur Thakur
42.	*Cyamopsis tetragonoloba* (L.) Taub.	Fabaceae	AK-44	Ghawar	Herb	Naue Kot
43.	*Cymbopogon jwarancusa* (Jones) Schult.	Poaceae	AK-89	Khatan	Herb	Bandhoo Lake
44.	*Dactyloctenium aegyptium* (L.)Willd.	Poaceae	AK-121	Mandahari	Herb	Khejrari
45.	*Datura innoxia* Mill.	Solanaceae	AK-41	Chario Datoro	Herb	Kunrian
46.	*Digera muricata* (L.) Mart.	Amaranthaceae	AK-45	Lalaur	Herb	Village Wakeel khan
47.	*Diplachne fusca* (L.) Stapf	Poaceae	AK-99	Ghae	Herb	Karemabad Gajo
48.	*Enicostemma hyssopifolium* (Willd.) Verdoon	Gentaceae	AK-51	More noke	Herb	Haidre Farm
49.	*Eucalyptus globulus* Labill.	Myrtaceae	AK-26	Bedmusk	Tree	Bhodasra road
50.	*Euphorbia granulata* Forssk.	Euphorbiaceae	AK-53	Daani walah	Herb	Marvi jo koah
51.	*Euphorbia hirta* L.	Euphorbiaceae	AK-111	Kaazi dustar	Herb	Marvi je Bhitt
52.	*Fagonia bruguieri* DC.	Zygophyllaceae	AK-120	Dramiho	Herb	Shahu Bhell
53.	*Fagonia cretica* L.	Zygophyllaceae	AK-110	Acho Dramiho	Herb	Gujarie
54.	*Fumaria indica* (Hausskn.) Pugsle	Fumaraceae	AK-122	Shah tero	Herb	Daro Mill village
55.	*Glinus lotoides* L.	Molluginaceae	AK-52	Panjdani	Herb	Qasboo village
56.	*Gnaphalium polycaulon* Pers.	Asteraceae	AK-76	Daandi boti	Herb	Naro Goath
57.	*Grangea maderaspatana* (L.) Poir.	Asteraceae	AK-78	Far	Herb	Villages Chachjro
58.	*Haloxylon stocksii* (Boiss.) Benth. & Hook. f.	Chenopodiaceae	AK-79	Nur Laano	Shrub	Shah Masri
59.	*Heliotropium bacciferum* Forssk.	Boraginaceae	AK-81	Khrasan	Herb	Chatan jo Koah

60.	*Heliotropium crispum* Desf.	Boraginaceae	AK-86	Kharsai boti	Herb	Chellar
61.	*Heliotropium europaeum* L.	Boraginaceae	AK-82	Hathi Sondi	Herb	Golarchi
62.	*Heliotropium strigosum* Willd.	Boraginaceae	AK-83	Vekar dani	Herb	Faqeer Samo Village
63.	*Hibiscus scindicus* Stocks	Malvaceae	AK-55	Gula Zaire	Herb	Faqeer Ali Muhammad Mahar near By Pass road
64.	*Indigofera cordifolia* Roth	Fabaceae	AK-90	Veekar	Herb	Deedar Mahar villag
65.	*Iphiona grantioides* (Boiss.) Anderb.	Asteraceae	AK-84	Hadri boti	Herb	Wajhat Mahar village
66.	*Ipomoea batatas* (L.) Lam.	Convolvulaceae	AK-88	Ghajar	Herb	Khapro
67.	*Ipomoea cairica* (L.) Sweet	Convolvulaceae	AK-59	Gulabi	Shrub	Goath Meer Allah Dino
68.	*Lathyrus aphaca* L.	Fabaceae	AK-56	Achi Matri	Herb	Qasbo Hill
69.	*Launaea procumbens* (Roxb.) Ramayya & Rajagopal	Asteraceae	AK-93	Bhatar	Herb	Taali Road
70.	*Lawsonia inermis* L.	Lythraceae	AK-57	Mandi	Shrub	Shahban Shah Near Achro thar pat
71.	*Lepidium sativum* L.	Brassicaceae	AK-95	Barsi	Herb	Rohi maie
72.	*Leptadenia pyrotechnica* (Forssk.) Decne.	Asclepiadaceae	AK-96	Khip	Shrub	Village Imam bux wah
73.	*Medicago lupulina* L.	Fabaceae	AK-29	Kandari	Herb	Sardar Ghulam Muhammad Mahar
74.	*Melilotus officinalis* subsp. *Alba* (Medik.)	Fabaceae	AK-61	Jhall	Herb	Chatan jo Koah
75.	*Melilotus albus* Medik.	Fabaceae	AK-117	Jhali	Herb	Pir pagro Paat
76.	*Mollugo cerviana* (L.) Ser.	Molluginaceae	AK-03	Hazar dani	Herb	Sardar Bhadur Ali
77.	*Moringa oleifera* Lam.	Moringaceae	AK-66	Sohanjro	Tree	Village Dhodar
78.	*Mukia maderaspatana* (L.) M.Roem.	Cucurbitaceae	AK-108	Khuta walah	Climber	Chetan Khumar
79.	*Nelumbo nucifera* Gaertn.	Nelumbonaceae	AK-65	Baeh	Herb	Dabho

80.	*Nerium oleander* L.	Apocynaceae	AK-72	Gul Zaire	Shrub	Bakhyoio
81.	*Neurada procumbens* L.	Neuradaceae	AK-13	Kandi Chapri	Herb	Allah Dino Junjo
82.	*Nicotiana tabacum* L.	Solanaceae	AK-101	Tamak	Herb	Faqeer Hasbani Village
83.	*Ochradenus baccatus* Delile	Resedaceae	AK-36	War walah	Herb	Lal Muhammad / Harchand Rai
84.	*Ocimum basilicum* L.	Lamiaceae	AK-67	Nazbo	Herb	Nangerparker
85.	*Opuntia dillenii* (Ker Gawl.) Haw.	Cactaceae	AK-42	Naag phan	Shrub	Allah Jurio / Dost Muhammad
86.	*Oxystelma esculentum* (L. f.) Sm.	Asclepiadaceae	AK-73	Akki walah	Climber	Javed Ali Bajir / Jamal Din
87.	*Parkinsonia aculeata* L.	Caesalpiniaceae	AK-85	Arbi Kandi	Tree	Chanessar Khan / Dhanesh Kumar
88.	*Peganum harmala* L.	Zygophyllaceae	AK-94	Hermal	Shrub	Kharoro Syed
89.	*Phalaris minor* Retz.	Poaceae	AK-91	Top	Herb	Chakar Khan / Kirshan Singh
90.	*Physalis peruviana* L.	Solanaceae	AK-74	Chamkani	Herb	Musaddiq Ali / Shafi Muhammad
91.	*Pithecellobium dulce* (Roxb.) Benth.	Fabaceae	AK-68	Jaleebi	Tree	Muhammad Qasim / Utam Das
92.	*Pluchea arguta* Boiss.	Asteraceae	AK-98	Faar	Shrub	Faqeer Abdullah
93.	*Polycarpaea spicata* Wight ex Arn.	Caryophyllaceae	AK-63	Sahni boti	Herb	Liaqat Ali / Harchand
94.	*Prosopis cineraria* (L.) Druce	Mimosaceae	AK-75	Kandi	Tree	Sekhro
95.	*Pulicaria boissieri* Hook.f.	Asteraceae	AK-11	Kholmir	Herb	Kaloi
96.	*Pulicaria undulata* (L.) C.A.Mey.	Asteraceae	AK-35	Farrah	Shrub	Village Kharoro Syed

97.	*Rhazya stricta* Decne.	Apocynaceae	AK-38	Miswaj	Shrub	Village Kolhi Daro umerkot
98.	*Rhynchosia acuminatifolia* Makino	Fabaceae	AK-92	Pati wallah	Climber	Alrahim Colony A Chhore Station Umerko
99.	*Rhynchosia capitata* (Roth) DC.	Fabaceae	AK-64	Jhali Matri	Herb	Otaq Haji Nawab Ali Rajar Dhoronaro Umerkot
100.	*Ricinus communis* L.	Euphorbiaceae	AK-46	Haran	Shrub	Rajput Mohalla Dhoronaro Umerko
101.	*Rumex dentatus* L.	Polygonaceae	AK-97	Palik	Herb	Rajput Mohalla Dhoronaro Umerkot
102.	*Salvadora alii* Rajput & Syeda	Salvadoraceae	AK-100	Acha peero	Shrub	Maheshwari Mohla Pithoro
103.	*Salvadora persica* L.	Salvadoraceae	AK-47	Jhaar	Shrub	Village Saeed
104.	*Schweunfurthia papilionaceae* L.	Scrophulariaceae	AK-104	Aki	Herb	Faqeer Samo Village
105.	*Senna italica* Mill.	Caesalpiniaceae	AK-107	Ghorwal	Herb	Village Mohsin abad, Deh
106.	*Senna occidentalis* (L.) Link	Caesalpiniaceae	AK-49	HadrI Phari	Herb	Pir Muhallah
107.	*Solanum americanum* Mill.	Solanaceae	AK-58	Pat peeron	Herb	Sonhari Masjid Shandadpu
108.	*Solanum incanum* L.	Solanaceae	AK-114	Jhangli Wakan	Herb	Faqeer Ali Muhammad Mahar near By Pass road
109.	*Solanum surattense* Burm. f.	Solanaceae	AK-113	Kandari	Herb	Village Shah Bux Umrani Deh Jamaro

						Taluka Shandadpu
110.	*Sonchus acaulis* Dum.Cours.	Asteraceae	AK-69	Jhazi	Herb	Muhala Haji Jan Muhammad
111.	*Sonchus arvensis* L.	Asteraceae	AK-06	Kapri boti	Herb	Khaskheli Mohalla, Berani, Taluka Jam Nawaz Ali
112.	*Sonchus oleraceus* (L.) L.	Asteraceae	AK-103	Jhazi pani	Herb	Village Yaqoob Shaikh Deh Chari Bux Pahore Taluka Sindhri
113.	*Tamarix aphylla* (L.) H. Karst.	Tamaricaceae	AK-106	Laie	Shrub	Village Yaqoob Shaikh Deh Chari Bux Pahore Taluka Sindhri
114.	*Taraxicum officinale* L.	Asteraceae	AK-119		Herb	Deedar Mahar villag
115.	*Tecomella undulata* (Sm.) Seem.	Bignoniaceae	AK-109	Rahorio	Tree	Deh Kantraai Mirwah Gorchani Village Haji Morio Khan
116.	*Tephrosia purpurea* (L.) Pers.	Fabaceae	AK-102	Jhangli Mattari	Herb	Molvi Muhammad Ishaque Bhurguri
117.	*Tephrosia uniflora* Pers.	Fabaceae	AK-123	Jhali mattari	Herb	Deh Hingorno Islamkot
118.	*Tetraena simplex* (L.) Beier & Thulin	Zygophyllaceae	AK-16	Hazar Dani	Herb	Road Dilyari
119.	*Tribulus terrestris* L.	Zygophyllaceae	AK-71	Kandero	Herb	Village Sakrio
120.	*Withania somnifera* (L.) Dunal	Solanaceae	AK-20	Chat pato	Herb	Balouch Paro Nagarparkar
121.	*Withania coagulans* (Stocks) Dunal	Solanaceae	AK-77	Paneer	Herb	Village Piprio Taluka

						Nagarparkar
122.	*Zaleya pentandra* (L.) C.Jeffrey	Aizoaceae	AK-124	Wahoo	Herb	Oderolal Village
123.	*Ziziphus nummularia* (Burm.f.) Wight & Arn.	Rhamnaceae	AK-116	Chanagori beer	Shrub	Malani House Mithi
124.	*Ziziphus jujuba* Mill.	Rhamnaceae	AK-87	Sofi beer	Tree	Village Haji Umer lashar

Section II

Ethnobotany of Medicinal plant species used for the Treatment of Veterinary Disorders of Livestock

3.2.1 Demographic data of the Studied participants

In total, 186 informants were interviewed for documentation of ethnobotanical data on veterinary disorders. Among interviewees, 17 were livestock experts, animals' healthcare traditional practitioners, camel trainers, dairy farmers, and shepherds, while 169 informants were local peoples. With respect to gender, 180 informants weremale while 6 were female. In most of the ethnobotanical studies, male informantswere found to be more common as compared to female. The main reason behind this may be restrictions on female informants to talk with male out of their families (Umair et al., 2017). In present study, due to many social and cultural factors the contribution of female informants was too less throughout the ethnoveterinary data documentation. Yigezu et al. (2014) also reported more dominant number of male health practitioners (94%) as compared to female practitioners (5.95%) and concludedthat male traditional health practitioners (THPs) were directly in healthcare practices in herbal clinics whereas females are not allowed to be involved in outdoor activities. In other study from Ethiopia, it was reported that medicinal plant species used for veterinary purposes is predominantly used by male (Feyera et al., 2017). In previous studies Butt et al. (2015), reported that the number of males is commonly found more in ethnobotanical studies due to ease of access at different places as compare to female informants due to discrimination of gender and restriction of families.

Local residents in the research region (Total 180: table 5) were found to be involved in conventional agricultural and pastoral activities, working as farmers, ranchers, and shepherds. Mahmood et al., (2011) presented comparable sorts of data on the local usage of plants obtained from diverse areas through meetings, interviews, dialogues, and conversations with rural, informed people, hakims, and shepherds in the literature. According to another study, farmers and pastoralists in various nations utilise medicinal herbs for the treatment of veterinary illnesses and animal healthcare (Hassan et al., 2014). Like previous studies, it was also observed in this study that *Hakeems* (THPs) and old aged people especially the people with experience of Animal husbandry were aware of different ethnoveterinary uses of medicinal plants.In this regard, it was observed that the experience in traditional systems of livestock treatment seems to be more important, but their knowledge is not properly documented. In literature, it is concluded that fast dwindling traditional knowledge

should be documented (Eshetu et al., 2015). Previous research has also found that traditional herbal healers' indigenous knowledge of the veterinary healthcare system is passed down orally from generation to generation (Devendrakumar and Anbazhagan, 2012). In present study, shepherds and camel trainers had more ethnoveterinary knowledge as compared to rest of informants. In literature, Yaseen et al. (2015) reported that ethnomedicinal knowledge is always common in the people who are directly linked to their culture. In another study, it was reported that traditional knowledge about treatment of ailments of animals is commonly found in shepherds and pastoralists (Geerlings, 2001). However, Gebrezgabiher et al. (2013), reported that traditional medicinal knowledge may be prevalent in rural people, as compared tourbanized one. It was also observed that traditional health practitioners had enough knowledge of treatment of animal.

In present study, most of the informants (total: 53) belonged to above 60-year age, and 45 informants had age of (50 to 59) years while only 07 informants were less than 20 years (Table 1). The majority uses were reported by elderly individuals who were actively involved in breeding and livestock (mainly farmers and shepherds) or who worked in agriculture, as predicted. The young generation had very important knowledge of ethnoveterinary practices of medicinal plants. In previous studies, it was commonly reported that traditional knowledge on herbal recipes for the treatmentis always prevalent in elders as compared to youngers. With respect to education, most of the informants (total 73) had 5 years of education followed by illiterate 45 informants having no school education. It was reported that most of illiterate informants cannot read or write but have oral knowledge using medicinal plants. In previous studies it is reported that less education level in an area is helpful to preservethe traditional knowledge (Assefa and Bahiru, 2018). Ijaz et al. (2015) reported that many informants in ethnobotanical studies are illiterate and less educated but have complete information of preparation of recipes and processing methods. In another report, Yirga et al. (2012) also mentioned that majority of the respondents were illiterate but have their interests of using medicinal plants for healthcare. In present study, the common prevalence of less educated informants is might be due to their interest, and occupation linked to livestock as compared to high educated people having less knowledge about ethnoveterinary medication.

It was reported that the experience of THPs is more important in ethnoveterinary studies. In our findings, it was found that the majority of THPs (total 06) had experience of 2 to 5 years while THPs with experience of more than 20 years were only 02. In literature, it is reported that the documentation of traditional ethnomedical knowledge from experienced THPs could play important role in preservation of this cultural heritage (Khattak et al., 2015). Ali-Shtayeh et al. (2016) also reported that the ethnobotanical knowledge of more experienced THPs is always more prevalent as compare the less experienced people. In this study, it was discovered that majority of nomadic THPs and informants had extremely knowledge of the sustainable use of medicinal herbs in the treatment of veterinary diseases.

Table 5: Demographic data of informants in Southern Desert of Sindh Pakistan

S. No	Variable	Categories	Participants	Percentage
1.	Category of Informants	THPs	17	8.62
		Local people	169	91.38
2.	Gender	Female	6	3.5
		Male	180	96.5
3.	Age	Below 20 years	07	2.87
		20 to 30 years	16	9.2
		30 to 40 years	28	13.22
		40 to 50	37	21.26
		50 to years	45	22.99
		Above 60 years	53	30.46
4.	Education	Illiterate	45	24.71
		05 years	73	39.08
		08 years	33	16.09
		10 years	15	8.62
		12 years	11	6.32
		Undergraduate	05	2.87
		Graduate	04	2.3
5.	Experience of THPs	Less than 2 years	3	13.33
		2 to 5 years	6	33.33
		5 to 10 years	3	20
		10 to 20 years	3	20
		More than 20 years	2	13.33
6.	Mother Language	Gujrati	29	15.52
		Dhatki/ Maharwaari	113	59.2
		Sindhi	39	22.41
		Urdu	05	2.87

3.2.2 Medicinal plant diversity of Veterinary diseases treatment

Ethnomedicinal plants species are found to be valuable in traditional healthcare of animals in the Southern Deserts of Sindh Pakistan. In present study, 57 highly precious medicinal plant species belonging to 29 families (Figure) and 59 genera were reported for the treatment of veterinary disorders. The reported ethnoveterinary important medicinal plants their local and botanical names, parts used, mode of administration, treated livestock and folk herbal recipes is presented in Table 6.

Out of 29 different families, 06 species belong to family Fabaceae followed by Amaranthaceae, Cucurbitaceae and Convolvulaceae (four species each) while remaining species belongs to Acanthaceae (three species), Asclepiadaceae (three species), Mimosaceae (three species), Zygophyllaceae (three species), Asteraceae(two species), Capparaceae (two species) Solanaceae (two species), Cleomaceae (two species), Poaceae (two species) and Chenopodiaceae (two species) as mentioned in figure 2. The remaining 15 (51%) families had a single species representation. The findings of Ali-Shtayeh et al. (2016) and Sharma et al. (2012) reported that Fabaceae species are commonly used in the treatment of various disorders including veterinary diseases.

In literature from Pakistan, (Bibi et al., 2014; Kayani et al., 2015) reported Asteraceae and Lamiaceae species were most commonly used plants in the traditional healthcare system. On other hand, in arid deserts and semi-arid regions Amaranthaceae and Fabaceae were commonly reported by (Ashfaq et al., 2019; Yaseen et al., 2015). The earlier study from Nara Desert reported Boraginaceae and Amaranthaceae species as the most dominant medicinal plants used in rural ethnic communities (Qureshi and Bhatti, 2008). In present study, the prevalence of commonly used species of Fabaceae, Amaranthaceae and Cucurbitaceae is due to their common use by pastoralists and THPs in healthcare practices of livestock. The increased use of this Leguminosae family might be attributed to its abundance in the research area. Similar research has been reported from other regions of the world (Assefa and Bahiru, 2018; Gonzalez et al., 2011) including Pakistan (Abbasi et al., 2013), where traditional healers mostly employ members of the Fabaceae family to

prepare traditional remedies to cure various animal and human illnesses. This finding disagrees with that of (Aziz et al., 2018; Ahmad and Murtaza, 2015; Tariq et al. 2014), who found the Apiaceae, Polygonaceae, and Asteraceae families to be the most commonly utilized during an ethnoveterinary survey. The difference across research might be attributed to the varied predominant vegetation of the locations or to traditional beliefs of different cultures in employing certain plants in traditional ways.

These plant species are of different botanical forms. The life forms of the reported species are mentioned in Table 1. Herbs were the most utilized plant form while shrubs and trees had lower frequency. The herbaceous flora constitutes highest contribution (63%) of the reported plant species followed by Shrubs (16%) andclimbers (10%). Trees and trailers represented only 9% and 2% respectively. Xiong etal., (2020) found an 80 percent contribution of wild herbs in medicinal plants utilised by indigenous populations in Southwest Guizhou, China. Herbs are frequently usedby indigenous people because they are easily accessible and have a high efficiency in the treatment of illnesses when compared to other living forms (Umair et al., 2017). Several earlier research on the dominance of herbaceous plants in the ethnomedicinal plant system agree with our findings (Yineger et al., 2008; Teklehaymanot and Giday 2010; Bhatia et al., 2014; Rao et al., 2015). Other research, on the other hand, found that shrubs and trees were the most employed living forms in ethnoveterinary treatments (Alebie and Mehamed, 2016; Lulekal et al., 2014; Yigezu et al., 2014). Herbs are commonly used by traditional healers in the region to treat their animals, which may be owing to the fact that herbs are readily available and easy to harvest when compared to other growth forms. The findings show an abundance of herbs in the research region, and their widespread use may be owing to herbaceous plants'great effectiveness against cattle diseases. The same findings were also reported from other studies conducted at various regions in thes world (Benitez et al., 2012; Luseba and Van der Merwe, 2006).

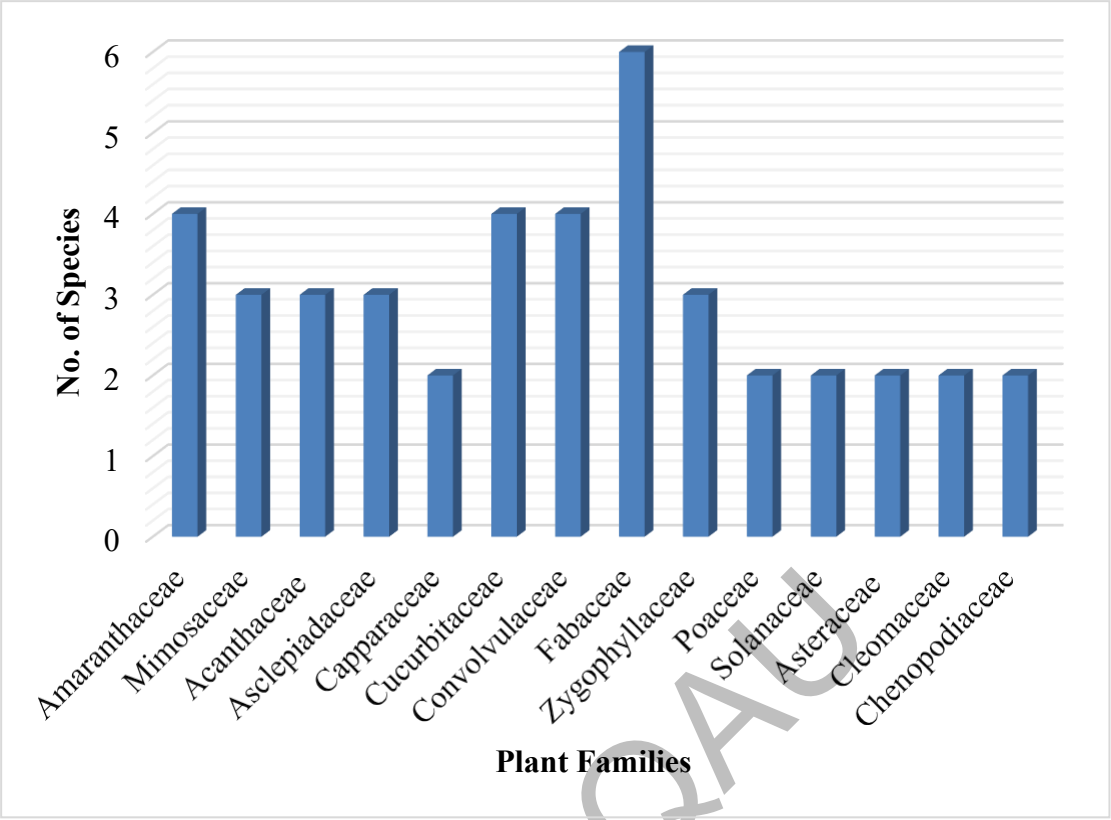


Figure 2: Graphical representation of dominant families of Medicinal plant species used in veterinary disorders

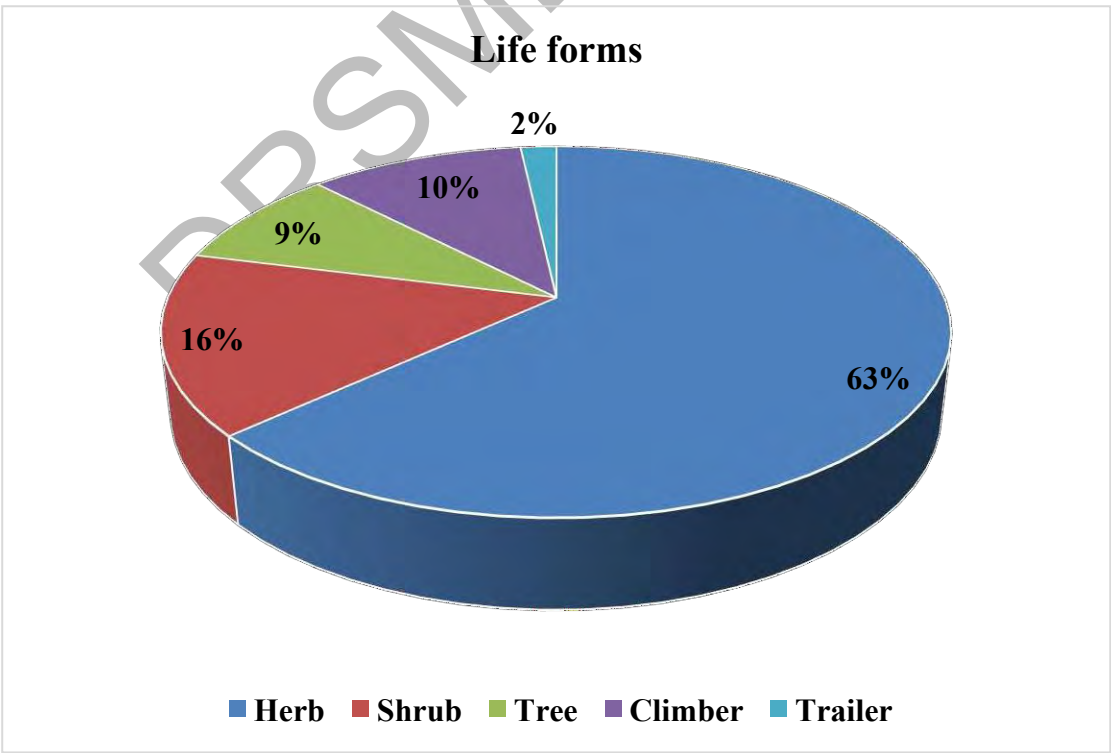


Figure 3: Graphical representation of Lifeforms of Medicinal plant species used in veterinary disorders species

Table 6. Ethnoveterinary documentation of medicinal plants in Sothern Deserts of Sindh

S.N	Botanical Name	Local name	Plant part used	Mode of utilization	Treated disease/ Uses	Treated animal	FC*1	UR*2	RFC*3	UV*4
1.	*Acacia nilotica* (L.) Delile	Babar	Seed, Leaves	Paste, Decoction	Cough, Joint Pain, Stomach worms, Smooth delivery	Goat, Cow, Camel, Sheep and Dog	35	02	0.136	0.057
2.	*Acacia modesta* Wall.	Babari	Leaves, Seed, Bark	Decoction, Paste	Swollen Nipple, Sexual potential, Cough, Eye infection	Camel, Cow, Buffalo, Goat and Sheep	39	03	0.152	0.076
3.	*Achyranthes aspera* L.	Ubtkandi	Whole plant, Stem, Root	Decoction, Paste	Urinary disorder, Joint pain, Skin infection, Retained placenta	Camel Buffalo Cow, Sheep and Goat	40	03	0.156	0.075
4.	*Aerva javanica* (Burm.f.) Juss. Ex Schult.	Booh	Leaves, Seed	Paste, Powder	Female reproductive infection, Increases milk production and stomach	Goat	38	4	0.148	0.105

					troubles					
5.	*Amaranthus viridis* L.	Morjhal	Whole plant	Raw	Increases milk production and fat, heal fractured horns	Cow and Goat	32	2	0.125	0.062
6.	*Arthrocnemum macrostachyum* (Moric.) K.Koch	Laaran	Leaves, Seed	Decoction	Stomach problem, Sexual power	Buffalo Camel, Cow, Goat, Sheep	34	2	0.132	0.058
7.	*Asphodelus tenuifolius* Cav.	Jungli Basri	Whole plant	Decoction	Nipple infection and Blood in Nipples, Expulsion of intestinal worms	Buffalo	44	2	0.171	0.045
8.	*Azadirachta indica* A.Juss.	Naeem	Seeds, Leaves, Fruit, Root	Juice, Decoction Powder	Gastric problems, Eye disorders, Skin disorders,	Cow, Buffalo Camel Sheep, Goat	39	4	0.152	0.102
9.	*Barleria prionitis* L.	Manymor	Whole plant, Seed, Flower	Decoction	Genital prolapsed Wound healing, mouth smell	Buffalo, Camel, Cow, Goat, Sheep	38	3	0.148	0.078

10.	*Barleria acanthoides* Vahl	Kandari	Leaves, Seed	Decoction Powder	Blood during in faces, Stomach disorder, Sexuality increases	Buffalo, Cow, Camel, Goat, Sheep	37	3	0.144	0.081
11.	*Blepharis scindica* Stocks ex T.Anderson	Asad	Whole plant, Leaves, Seed, Root	Decoction Powder	Neck infection, Joint pain, Urinary disorder	Buffalo Camel, Cow, Goat, Sheep	41	4	0.160	0.097
12.	*Boerhavia procumbens* Bank s ex Roxb.	Satti	Flower	Decoction	Sexual potential	Cow, Goat, Camel and Buffalo	33	1	0.128	0.030
13.	*Calotropis procera* (Aiton) Dryand.	Akk	Leaves, Latex	Decoction/ Paste	Joint pain legs, Brain infection, Vaginal thrush	Camel, Cow, Buffalo, Sheep, Goat	36	2	0.140	0.055
14.	*Capparis spinosa* L.	Berri Whalah	Root, Fruit, Leaves	Decoction	Liver infection, Gall bladder, Skin diseases	Cow, Camel, Goat, Sheep, Donkey	39	3	0.152	0.076
15.	*Capparis decidua* (Forssk.) Edgew.	Kirar	Flower Stem Root	Powder Decoction	Bone fracture, Nasal bleeding, Nipple infection, Lungs	Buffalo Cow, Sheep, Donkey, Goat, Camel	41	4	0.160	0.097

					disorder, Genital prolapse					
16.	*Chenopodium murale* L.	Janghali Lulhar	Leaves Seed	Decoction Powder	Constipation, Gall bladder infection, Milk production	Especially Buffalo Camel, Cow, Sheep, Goat	35	3	0.136	0.085
17.	*Citrullus colocynthis* (L.) Schrad.	Trooh	Whole plant Fruit Leaves Root	Decoction Powder	Food poisoning and internal infection of liver and joint pain, Diarrhea, Mastitis	Camel, Sheep, Buffalo, Cow, Goat, Sheep, Horse, Donkey	39	4	0.152	0.102
18.	*Cleome brachycarpa* (Forssk.) Vahl ex DC.	Bhoi phli	Whole plants Leaves Seed	Decoction Powder	Skin infection, Joint pain, Testicles swellings	Camel, Cow, Goat, Sheep,	34	2	0.132	0.058
19.	*Cleome viscosa* L.	Kinni, Butti	Whole plant Seed	Paste Decoction Powder	Removal of Leach and Infection of Nipples, external worms of the skin	Buffalo Camel, Cow Dog,	39	4	0.152	0.102

					diseases					
20.	*Coccinia grandis* (L.) Voigt	Sitari wallah	Seed, Leaves Flower	Powder Paste Raw	Hoof infection, Muscular disorder, Foot, Mouth disease	Cow, Camel, Goat, Sheep	40	3	0.156	0.075
21.	*Convolvulus arvensis* L.	Naaro	Whole plant	Raw	Increase in milk production	Goat, Sheep	40	1	0.156	0.025
22.	*Corchorus depressus* (L.) Stocks	Mundheri	Whole plant Leaves Root	Juice	Sexual tonic, Urethral disorder	Goat, Camel, Cow, Deer, Sheep	36	2	0.140	0.055
23.	*Cressa cretica* L.	Utah Charo/ Oin	Whole plant	Decoction	Dehydration, Stomach trouubles	Goat, Camel Sheep, Cow, Buffalo	36	1	0.140	0.027
24.	*Crotalaria burhia* Benth.	Feer, Makhan booti	Whole plant Root Seed	Paste Decoction	Breast infection, Dysentery, Blood along with feces,	Camel, Buffalo Cow, Sheep, Goat	40	3	0.156	0.075
25.	*Ctenolepis cerasiformis* (Sto cks) C.B.Clarke	Bari walah	Whole plant Fruit	Powder Decoction	Stomachache, Spleen Enlargement, Gastric	Cow, Camel, Goat, Sheep	33	2	0.128	0.060

					distension					
26.	*Cyamopsis tetragonoloba* (L.) Taub.	Ghwar	Whole plant Seed	Decoction	Old cough, Dehydration Bone weakness, Salt poisoning	Camel, Cow, Sheep, Goat,	38	3	0.148	0.078
27.	*Cymbopogon jwarancusa* (Jones) Schult.	Kattan	Whole plant	Decoction	Fever, Joint pain, and increase in milk production, Leech infestation in cows.	Cow, Sheep, Goat, Camel	33	3	0.128	0.090
28.	*Digera muricata* (L.) Mart.	Lulur	Whole plant Seed	Decoction	Urinary bladder ulcer and increase milk fat	Sheep, Cow, Goat, Camel, Donkey Sheep	40	3	0.156	0.075
29.	*Fagonia bruguieri* DC.	Dramaaho	Whole plant, Leaves Seed	Decoction Powder	Skin Diseases, fever, Cancer and Use for Fodder	Buffalo Camel, Cow, Goat, Sheep	46	4	0.179	0.086
30.	*Fumaria indica* (Hausskn.) Pugsley	Shahatro	Whole plant	Juice Decoction	Ear diseases, Dysentery,	Camel, Buffalo, Cow,	43	2	0.167	0.046

					Indigestion, colic	Goat, Sheep, Dog				
31.	*Heliotropium bacciferum* Forssk.	Khrasan	Seed	Decoction Raw	Increase in milk production and in fat milk	Sheep, Cow, Goat	34	2	0.132	0.058
32.	*Ipomoea batatas* (L.) Lam.	Ghajarla hori	Whole plant Seed	Powder Decoction	Joint pain, Food Poisoning, Anthrax	Cow, goat, camel,	41	2	0.160	0.048
33.	*Ipomoea carnea* Jacq.	Pholi	Flower Seed	Decoction	Stomach disorder, Sexual tonic, Ectoparasites infestation	Camel, Cow, Sheep, Goat,	37	2	0.144	0.054
34.	*Lathyrus aphaca* L.	Achi Matari	Whole plant	Raw	Increase in milk production	Goat, Sheep	36	1	0.140	0.027
35.	*Leptadenia pyrotechnica* (Forssk.) Decne.	Khup	Whole plant Seed	Decoction	Urinary disorder, Mouth infection	Cow, Buffalo, Camel Sheep, Goat	34	2	0.132	0.058
36.	*Melilotus officinalis* subsp. *alba* (Medik.)	Jhal	Whole Plant, Flower	Decoction Powder	Urinary abnormalities, Sexual increase	Cow, Camel, Goat, Sheep, Donkey	35	2	0.136	0.057

37.	*Mukia maderaspatana* (L.) M.Roem.	Khuta wallah	Leaves Fruit Seed	Paste Powder decoction	Skin infection, Sexual tonic, Lamb dysentery	Cow Camel, Buffalo Goat, Sheep	34	2	0.132	0.058
38.	*Nelumbo nucifera* Gaertn.	Bhaeh	Leaves Rhizome Flower Seed	Decoction Powder	Diarrhea, Gastric ulcer, Nasal bleeding, Uterus prolapse	Cow, Goat, Camel and Buffalo	42	3	0.164	0.071
39.	*Opuntia dillenii* (Ker Gawl.) Haw.	Thohar	Bud Root Leaves	Decoction Powder Juice	Anestrous, Snake bite, Retention of placenta	Buffalo Cow, Camel, Sheep, Goat, Donkey Dog	37	3	0.144	0.081
40.	*Oxystelma esculentum* (L. f.) Sm.	Sohni boti	Latex Flower Leaves	Juice Powder Decoction	Female reproductive infection, Joint pain, Brain infection	Cow, Camel, Buffalo, Horse, Donkey	43	3	0.167	0.069
41.	*Phalaris minor* Retz.	Topi	Whole plant,	Decoction	Dehydration Increasing milk production	Buffalo Camel, Cow, Goat, Sheep	39	2	0.152	0.051
42.	*Prosopis cineraria* (L.) Druce	Dewi	Seed, Leaves	Juice, Powder	Body weakness, Eye infection, Increase	Goat, Camel, Cow, Deer, Sheep	43	2	0.167	0.046

					lactation					
43.	*Pulicaria boissieri* Hook.f	Kolmir	Leaves Seed	Decoction Paste	Leach removing, Internal parasite, Wound healing	Buffalo Cow, Camel, Goat, Sheep	35	2	0.136	0.057
44.	*Rhynchosia acuminatifolia* Makino	Jhali Badmi	Leaves Seed	Decoction Powder	Urinary disorder, Bone weakness, To remove leeches	Buffalo Camel, Cow, Goat, Sheep	38	2	0.148	0.052
45.	*Rhynchosia capitata* (Roth) DC.	Mattarw allah	Leaves Flower	Decoction Paste	Fever, Urinary disorder, Internal and external parasite	Buffalo, Camel, Cow, Goat, Sheep	39	2	0.152	0.051
46.	*Salvadora alii* Rajput & Syeda	Achha peroon	Root Soft bark Leaves	Decoction Powder Juice,	Constipation, Gastric disorder, Urinary disorder	Camel, Cow, Sheep, Goat,	40	3	0.156	0.075
47.	*Schweunfurthia papilionaceae* L.	Aki	Whole plant Seed leaves	Decoction Powder	Reproductive disorder Respiratory disorder, Joint pain,	Sheep, Cow, Goat, Camel, Donkey, Sheep	43	3	0.167	0.069

					Rabies					
48.	*Senna italica* Mill.	Ghorwal	Whole plant Seed Root, Leaves	Powder Decoction	Joint pain, Breast Swollen, Removal of placenta after delivery, Old cough	Camel, Cow, Buffalo Goat, Sheep, Horse, Donkey	50	6	0.195	0.12
49.	*Solanum surattense* Burm. f.	Kandi	Whole plant Leaves Root	Decoction Powder	Joint pain, Old cough, Spleen infection, Black leg	Buffalo Cow, Camel, Sheep, Goat, Donkey Dog	48	3	0.187	0.062
50.	*Solanum incanum* L.	Jhagli wakan	Seed Root Leaves	Powder Decoction Juice	Genital prolapsed, foot infection, Mouth infection, Placenta replacement	Camel, Cow, Buffalo Goat, Sheep, Horse, Donkey	40	4	0.156	0.1
51.	*Tamarix aphylla* (L.) H.Karst.	Laie	Leaves Bark Flower	Decoction Powder Paste	Nipple cancer, Bone fracture, Urinary disorder, Body	Camel, Cow, Buffalo Goat, Sheep, Donkey	42	4	0.164	0.095

					part swollen					
52.	*Taraxacum officinale* L.	Jahaz	Whole plant	Powder	Swollen Esophagus, Tongue infection, Lumpy skin disease	Camel, Cow, Buffalo, Goat, Sheep	41	3	0.160	0.073
53.	*Tecomella undulata* (Sm.) Seem.	Mario	Bark, Seed Flower	Decoction Paste	Syphilis, Liver disorder, Urinary disorder, Calf pneumonia	Goat, Sheep, Cow, Camel	44	3	0.171	0.068
54.	*Tetraena simplex* (L.) Beier & Thulin	Hazar dani	Whole plant, Seed	Decoction/ Powder	Urinary disorder, Gastric disorder, Mastitis	Buffalo Camel, Cow, Goat, Sheep	36	2	0.140	0.055
55.	*Tribulus terrestris* L.	Sarang	Whole plant Seed	Decoction	Gall bladder infection, and increases in milk production	Goat, Sheep, Cow, Camel	41	2	0.160	0.048
56.	*Zaleya pentandra* (L.) C. Jeffrey	Wahoo	Whole plant Seed	Decoction	Cough, Dehydration,	Camel, Cow, Sheep, Goat,	38	2	0.148	0.052

					Diarrhea, Inflammation in small intestine					
57.	*Ziziphus nummularia* (Burm.f.) Wight & Arn.	Beeri	Leaves Seed	Decoction Powder	Stomach disorder, Gastric disorder, Indigestion	Buffalo, Camel, Cow, Goat, Sheep	45	2	0.175	0.044

FC*[1]= Frequency of Citation
UR[*2] = Use Reports
RFC[*3] = Relative Frequency of citation
UV[*4] = Use Value

3.2.3 Important Phytotherapies Used in the Diseases of Animals

Aerva javanica

Roots (230 grams) are boiled in water and decoction is given twice a day and seeds are used in cases of diarrhea and hematuria (blood in urine) in cattle. Whole in sheep and bull. Leaves burnt to create a smoke ring around animals as a fly repellant.

Barleria acanthoides

Its root is crushed (450 gram) to extract the juice and given to animal orally derived in boil water eliminate internal body worms and increase sexuality.

Blepharis scindica

Mix 100 gram of leaves with olive oil, heat, apply as poultice to the neck infection areas in sheep and cows. Fresh leaves are given to cattle as a galactagogue agent. For treating neck infection, 740 gram of whole dry plant is grinded and then mixture is boiled in water for 5 minutes. This decoction is given to animals 2 times a day for 3 days.

Capparis decidua

In total, 30 grams young shoots grated/mixed well with 20 grams *Capsicum annuum* and covered with clay, poured into wound and covered with clay against nasal bleeding. 50gm of dry fruit powder is fed to affected animals twice daily for 2-3 days to get rid of genital prolapse. 0.5 to 1 kg ash of mixed branches in 1 L water and applied topically for lice infestation and lung infections in goat and sheep. Fruit is used to cure diarrhea in cattle and goats. Bark powder is used in cases of nipple infection and indigestion. The plant is burned and then the burned twigs are grinded to fine powder and mix with whey and are given to animal to for removal of gas in digestive tract. Bone fractures in cattle and buffaloes were healed with 500 gram seeds grinded and then mixed in 1 L of water and administer for 3 days.

Citrullus colocynthis

500 grams of fruit mixed well with 250 gram common and black salt and give 50 to 100 grams for 2 to 3 days to cure food poisoning. 100 grams fruits are mixed with 50 grams whole plant of Solanum surratense and this mixture is given orally for curing infection of liver and joint pain. Fruits are also fed to cattle for improving digestion. Ash of dried burnt plant is mixed in honey and is used to treat wounds in animals. Roots juice are used against diarrhea and jaundice. Dried fruit is ground into powder and then mixed with common salt and the preparation is given to cattle and camel in cases of rheumatism. Dried Citrullus mixed with rock salt, Ajwain and Methi is given to the animal to cure breast tissue.

Salvadora alii

Peelon (dried fruit) is used to treat rheumatism in animals. Dried fruit (340 gram) is given to animals after parturition during winter to facilitate the expulsion of lochia. The filtered juice of root help in expelling of placenta in cows. Feed leaves (250 gram) as such for 4 days used against gastric disorders in cattle and buffaloes. Leaves are given as feedstuff twice daily to goats and cows to increase the milk production and cure constipation. Bark and stems are crushed, soaked in water and filtered through cloth. Topically applied to treat urinary complaints.

Coccinia grandis

Equal amount of warm leaf paste (630 gram) of the plant, ginger juice and garlic (Allium sativum) juice is given twice daily as a blood purifier in sheep and cow. Leaf is ground with ghee and the extract obtained is poured into affected parts to cure wounds and hoof infection in cow and goats. Leaf juice prepared from equal amount of Coccinia grandis and Peganum hermala and applied externally of cattle for mouth disease. The leaf juice was poured on the nose of the camel.

Corchorus depressus

600 grams fresh whole plant are grinded mix with 250 grams old date palm is boiled for 9 minutes. This mixture is given to cow, deer, and sheep for treating urinary disorders.

Mukia maderaspatana

Fresh leaves (800 gram) are made into a paste and taken orally to cure skin infection and intestinal worms in sheep and buffalos. The herbal leaves should be fried in the neem oil and administered orally once a day for one day. Animal will recover within 1-2 days in cattle against lamb dysentery.

Fagonia bruguieri

The extract derived after immersion of whole plant (240 gram) in one and half liter water for about 10 hours, orally administered to reduce body fever in sheep and buffalos. The decoction is used to cure cancer in camel and goat. Also used to treat skin diseases.

Tecomella undulata

200 mL root decoction is mixed with 200 grams root decoction of *Zizyphus nummularia* and given to treat liver disorders in bodies of cow and goat. Dilute decoction to wash infected eyes. Bark paste applied along with other herbs for calf pneumonia and also given orally to treat genital prolapse. Used for bursting opening of hypodermal blisters and also for urinary complaints.

Solanum surrettense

Grind five to six seed grain, added to them three cup gurr syrup applied orally through bottle for three nights consecutively to cure joint pain, and old cough. Grinded fruit (520 gram) mixed either in pasted flour or orally given in bread pieces to cure spleen infection. *Solanum surrettense* leaves boiled in 2 L water and drench decoction used once daily and repeated the treatment for one week to black leg troubles in cow.

Solanum incanum

Ingredients should be ground and administered orally followed by drenching of 200 ml of neem oil should be given during days of estrus and then inseminated after 24 hours of administration of medicine in hoarse for placenta replacement.0.5 kg fresh plant boiled in water along with salt, and yoghurt then the mixture is administered orally to animals 15 to 20 days for the treatment of foot and mouth infection. Juice from crushed petals and buds is mixed with 1 chatak salt and a little

amount of pure water and applied in cows or buffaloes at 6-hour interval for the treatment of genital prolapse.

Senna italica

Roots are boiled in water and 1 L in a bottle is given to sheep and 0.5 L to cows orally to cure ailments of joint pains. For treating Breast swollen, 500gm dry seed are grind combine up with 300gm gurr to make decoction in boiling water for 12 mints. This mixture is given to animals 2 time a day for 5 days for the removal of placenta after delivery.

Tamarix aphylla

Peel (125 gram) of Punica granatum and 0.25 kg crushed bark of Tamarix aphylla were grinded into powder. The powder is then mixed in water and decoction is given orally 2 times a day for 3-4 days for curing nipple cancer in buffalos. 125- gram bark of Tamarix aphylla and 250-gram raw sugar is crushed, and the powder mixture is given orally to the cattle 3-4 time a day to get relief from swollen body parts. Ash of bark mixed with Vaseline is applied over bone fractures and any burnt injury in donkey.

Crotalaria burhia

The whole plant is utilized as veterinary medicine, the whole plant is crushed (460 gram) with water and given to the animal to cure breast infection and it is also used for dysentery and swelling of the body tissues.

3.2.5 Plant Parts Used in the treatment of Veterinary Diseases

In folk herbal recipes, various plant parts were used for treating different diseases of livestock in the study area. The most used plant parts were whole plant (27%) followed by seed (25%), leaves (22%), root (10%), flower (8%), fruit (4%), bark (3%) and latex (1%) as mentioned in figure 4. Previous research suggests that thewhole plant is the most commonly used part in ethnoveterinary investigations in Pakistan and China (Khattak et al., 2015; Shen et al., 2010). The reported reason behind the common use of whole plants was easy to collect as compare to other parts such as fruits, leaves and flowers (Khuankaew et al., 2014).

Commonly leaves are predominately reported because leaves exhibit various pharmacological properties due to presence of various active compounds such as flavonoids and phenolics. Giday and Teklehaymanot (2013) and Yirga et al., (2012) also indicated that leaves were the most frequently used plant part to treat livestock ailments which agrees with current study. According to Maphosa et al., (2010) the use of leaves offers a conservation advantage over the usage of whole plants, roots, and tubers, which are damaging and not sustainable. The whole plant and leaves, according to Malla and Chhetri (2012), are the most often used plant parts for the treatment of various types of veterinary disorders. In contrast to this study, Lulekal et al., (2014) discovered that the root is the most utilized component. This disparity might be explained by the fact that the pharmacological value and concentration of active substances in each plant differed depending on climatic and edaphic variables. According to Sori et al., (2004), people from various ecological zones use different plants and plant components in their therapy. Benarba, (2016) reported that in ethnomedicinal studies, leaves and seeds are commonly used due to their therapeutic potential that depends on variety of active compounds. The prevalence of leaves as the part utilized are common findings in ethnoveterinary and ethnopharmacological studies (Monterio et al., 2011; Ritter et al., 2012; Antonio et al., 215). The distinction between veterinary and human medicine is that for human treatments, people pick plant parts with greater care, removing flowers from stems, but for ethnoveterinary applications, people utilize the full aerial portion or blooming stems, including stems and leaves, rather than just flowers. In addition to stems and leaves, the entire plant, subterranean portions, and bark are used in ethnoveterinary treatments (Benitez et al., 2012).

3.2.5 Mode of Utilization in the treatment of Veterinary Diseases

In the present study, various modes of utilization of herbal recipes werereported (Figure 5). To cure the ailment, many modes of administration are employed,which may be classified into internal administration and exterior administration of preparation. Among reported modes, the decoction was commonly reported (47%), followed by powder (28%) and paste (12%), while least mode was raw and juices. These methods are some of the practical ways indigenous healers can use when preparing and applying medicines to animals. For the most part, these herbal remedies were made from a combination of several plant species to cure a particular condition. Plant cures were mainly made from fresh plant material, followed by dried plant material.

Yigezu et al., (2014) discovered that healers have been employing various ways of traditional medicine preparation for various sorts of cattle illnesses in a prior research. The preparations differ depending on the type of sickness being treated and the location of the problem. Preparation of ethnoveterinary recipes by traditional healers reported formerly by (Tariq et al., 2014) are also in the form of powder and decoction. Maphosa and Masika, (2010) and Ahmed and Murtaza, (2015) reported decoction as dominant form of utilization. In ethnobotanical studies, decoctions are always commonly reported. Plant material is boiled in water or another liquid for a given amount of time to prepare decoction. It is reported that on boiling of plant material various active compound are extracted in liquid which are responsible for therapeutic potential (Ahmad et al., 2008; Ramawat et al., 2009). In other studies, Yaseen et al. (2019) it was concluded that decoction may be responsible for synergetic effect of herbal recipes that are made from two or more plant species. According to Tabuti et al., (2003), veterinary herbal medicines are prepared as infusions and seldom as decoctions was found contradicting with the findings of present study. In present study, *Achyranthes aspera*, *Blepharis scindica Citrullus colocynthis*, *Cressa cretica*, *Fagonia bruguieri* and *Mukia maderaspatana* were commonly reported for decoction. The most common category of therapeutic formulations was decoction and preparation methods of the therapeutic materials sometimes varied e.g., the same plant material for the same disorder could be prepared in different ways, depending upon the preferences of different healers (Ali- Shtayeh et al., 2016).

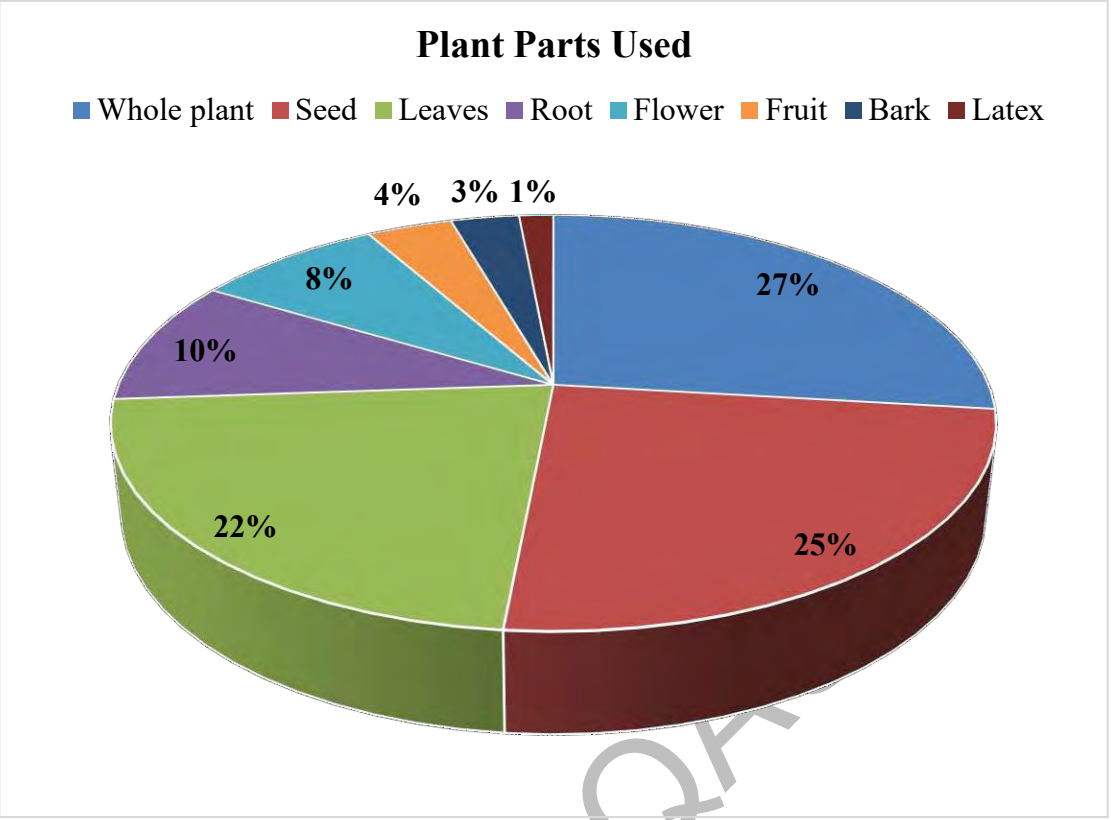


Figure 4: Plant part used in herbal recipes for treatment of Veterinary diseases

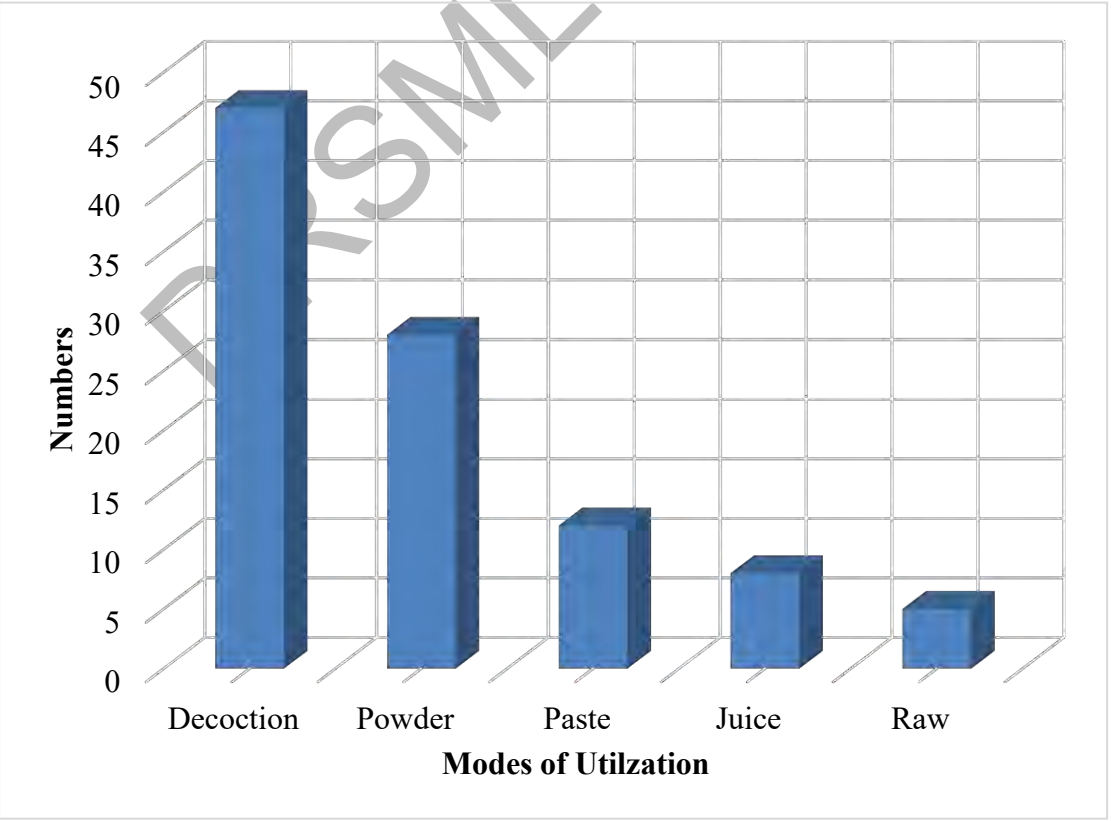


Figure 5: Modes of Utilization of herbal recipes for the treatment of Veterinary diseases

3.2.6 Most Commonly used plant species in Veterinary disorders

In present study, the rich heritage and cultural knowledge regarding ethnoveterinary uses of precious plants in the deserts of Southern Sindh was reported. Among reported plant species, the most used species were *Senna italica, Solanum surrattense, Fagonia bruguieri, Fumaria indica, Mukia medraspatana, Opuntia dillenii, Tamarix aphylla* and *Tribulus terrestris*. *Senna italica* was commonly reported for removal of placenta after delivery of fetus, infections on nipples and jointpain. In literature, *Senna italica* bark is reported against Diarrhea and gall sickness treatment in cattles (Luseba and Van Der Merwe, 2006). In South Africa, it was described that its root decoction is used for curing general ailments in cattle (McGaw and Abdalla, 2020). Extract of bark and roots are applied for treatment of intestinal disorder, anthrax and pneumonia (Van der Merwe et al., 2001). *Senna italica* choppedroots infusion was used as ethnoveterinary practices to treat calf diphtheria (Gabalebatse et al., 2013). Root infusion is also used as eye drops for sore eyes (Sasidhar et al., 2016). In earlier studies, *Senna italica* root poultice is applied topically to retained placenta and showed detoxification of liver (Moichwanetse et al.,2020).

Solanum surrattense was reported against enlarged spleen, respiratorydisorders, and skeletal disorders of different animals. In previous studies the fruit is commonly reported in ethnoveterinary studies against Colic and worm infestation (Khan et al., 2015). It is also reported for the treatment of to cure abdominal pain, metritis and retained placenta after birth, cure abdominal pain and stomach swellings (Khan et al., 2019). Flower juice from crushed petals and buds applied to eyes of cows or buffaloes to frequently treat watering of eyes (Rahmatullah et al., 2010). In various veterinary therapies leaves are found to be effective against for genital prolapse (Dilshad et al., 2008). The whole plant boiled decoction of *Cymbopogon jwarancusa* was effective against fever treatment and joint pain given to animals 3 times a day for 3 days. According to Qureshi et al., (2010) and Majeed et al., (2020), a decoction of *C. jwarancusa* was administered to cattle for placenta replacement and totreat reproductive disorders in animals.

Fagonia bruguieri was reported for infections related to blood, such as blood cancer and skin infections of animals. In study area, *Fagonia bruguieri* is considered as best fodder for the good health of livestock. In literature, it is commonly reported for the ectoparasitic problems (Katerere and Luseba, 2010). Whole plant decoction of *F. arabica* is useful as cooling agent for stomach of horse and donkey (Khattak et al., 2015). While *F. indica* decoction is given to camels for treatment of cough (Kumar et al., 2004). A*sphodelus tenufolius* was commonly documented for release of blood along with milk from nipples. It was found to be most effective species for these infections. In previous studies, *Asphodelus tenufolius* leaves were used to cure weakness in horses, while others have reported that root paste of this plant is appliedto wounds in cattle (Abbasi et al., 2013; Ali, 1999). Its leaves and shoot were also documentated against paralysis in cow previously (Sher and Aldosari, 2013). *Fumariaindica* was commonly documented for ear infections of cattle. Suroowan et al., (2017)reported it to feed the cattle for curing gastric problems These plant species are regarded as diuretic and diaphoretic, used in chronic skin infections, dyspepsia, liver complaints and leprosy. Its decoction is considered as useful in blood purification. antipyretic, carminative, diaphoretic, and laxative. In various biological activities, it is recommended for cardiovascular and anxiety disorders.

In present study, *Mukia medraspatana* decoction of grinded fruits and seeds was given to animals for increasing sexual tonic and prolapsed of uterus.Bhuvaneswar et al., (2015) reported that *M. medraspatana* fresh leaves are made intoa paste and taken orally to cure throat infection in sheep and bulls. External application of leaf paste is used to treat foot and mouth disease (Yogeswari et al., 2017). *Opuntia dillenii* was reported in this study against snakebite treatment and for placenta retention. Although *O. dillenii* fruits juice is given orally for 3-4 days twice aday for therapy of diarrhea in sheep's and goats (Panda et al., 2017). The boiled decoction of the dry leaves of *Tamarix aphylla* was given to animals for breast cancer treatment. The ash of bark combined with Vaseline may be used on broken nipples and any burned injury in Buffalo, according to Yadav et al., (2014). The dry seeds paste of *Tribulus terrestris* was used in the treatment of gall bladder in goat andsheep. The earlier studies of (Kidane et al., 2014) indicated that whole plant extract is chopped for curing foot rot disorder.

3.2.7 Quantitative Ethnoveterinary data

In present study, for quantitative analyses, use reports, used value and relative frequency of citation indices were applied.

a) Use Reports

A usage report (UR) is a single-person citation of a single plant species for a specific purpose. There will be many Use reports for a multi-purpose plant documented by a single informant (Odonne et al., 2013). In the present study, the use reports ranged between 1 and 13. The highest use report were documented for *Senna italica (*6 reports), *Aerva javanica, Blepharis scindica, Capparis decidua, Solanum* incanum and *Tamarix aphylla* (4 reports each). and least use values were reported for *Boerhavia procumbens, Convolvulus arvensis, Cressa cretica* and *Lathyrus aphaca (*1 report each). Although it was impossible to match the quantitative data within the region particularly in the Deserts of Sindh, due to few quantitative works have been done in the other parts of the Sindh (Yaseen et al., 2015, Saand et al., 2019), but there is a clear difference regarding most reported species and their quantitative values. Medicinal plants with high URs strengthen the concept that such species are more significant to the local population and useful when sharing traditional knowledge. These species were used for the treatment of breast swallowing, removal of placenta, gastrointestinal complaints, urinary disorders, reproductive tract infections, genital prolapsed and nipple infection while species with the least reported use report was used to increase sexual potential, milk production, measles treatment and calf hair loss. The medicinal plants with respect to treat livestock disorders, most use reports can be assessed for pharmacological activity and toxicity validity (Panmei et al., 2019).

b) Used Value (UV)

The use value (UV) is a quantitative technique for data analysis that authenticates the relative importance of species or family for a population (Zenderland et al., 2019). The use value ranged from 0.025 to 0.135. In this investigation, the high UVs recorded for *Solanum incanum* (0.1) followed by *Aerva javania* (0.105), *Citrullus colocynthis* and *Cleome viscosa* (0.102). entitle their extensive practice in the ethnoveterinary custom in the assessment area. The lowest UVs were attained for *Convolvulus arvensis* (0.0225). The earlier study of Bibi et al.,

(2014) reported UV of *S. incanum* was used against sore throat, *C. viscosa* used value in previous studies was documented for worm expulsion (Issa et al., 2018). The previous findings of Barkaoui et al., (2017) cited the used value for *Citrullus colocynthis* against skin spots in cows and *Aerva javanica* for their leaves burnt to create a smoke ring around animals (Farooq et al., 2008). Rashid et al., (2015) reported that the plant species that are commonly used in study has always the highest use value. High use values can be attributed to its frequent use in the treatment of various livestock diseases with high use value reported and number of informants showing that it is well accustomed by all the informants as an ethno-veterinary medicinal plant. In literature, plant species with highest use value may be selected for further experimental studies in drugs discovery development (Cerqueira et al., 2020). In present study it is observed that plant species with highest use value are commonly used by local people for ethnoveterinary medicine.

c) Relative Frequency of Citation (RFC)

The relative frequency of citation is applied to highlight the reported plant species based upon the local province. The ethnomedicinal plant species with high RFC values suggested their widespread use and knowledge among local communities (Faruque et al., 2018). To determine quantitatively the most common occurring medicinal plants used for livestock ailments, RFC was calculated. In present study, the RFC value shows the prominence of medicinal plant species used against ethnoveterinary diseases at various localities of the study area. It ranged from 0.125 to 0.195. The most important species on the base of RFC are: *Senna italica* (RFC = 0.195), *Solanum surattense* (0.187) and *Fagonia bruguieri* (0.187). (0.179). The high value of RFC describes the fact that these medicinal plant species were well known to many numbers of the local people in the study area. The lowest RFC value was recorded for *Amaranthus viridis* (RFC = 0.125). Tshikalange et al., (2016) reported RFC value for *Senna italica* for stomach ache problems in goats. While the RFC value in literature for *F. bruguieri* reported for urinary complaints in livestock (Bibi et al., 2014). The previous findings of Umair et al., (2017) showed that the highest RFC value of *Solanum surattense* against wound healing. In various studies, it is showed that plant species with local prominence have highest relative frequency of citation (Khan and Razzaq, 2018) and such species should be preferred over other during selection of species for further phytochemical and pharmacological activities (Amiri

et al., 2012). Reason for the high RFC may be wide distribution, easy availability and indigenous culture for treating various ailments by using these species. These results may be taken as most important for linking and evaluating research in related academic disciplines for future drug discovery and sustainable use of plants for therapeutic uses among livestock.

3.2.8 Summary

This study is confined with documentation of ethnoveterinary uses of medicinal plants of Southern Deserts of Sindh-Pakistan. A total of 57 plant species belonging to 29 plant families were reported from 186 studied participants using semi-structured, open ended and group interviews. The most cited families wereFabaceae (06 species) followed by Amaranthaceae Convolvulaceae and Cucurbitaceae (4 species each) while most of species belongs to herb life form (36 species). Among reported plant species, *Senna italica, Solanum surrattense, Cymbopogan jwarancusa Fagonia bruguieri, Fumaria indica, Mukia medraspatana, Opuntia dillenii, Tamarix aphylla* and *Tribulus terrestris* the most important among informants and regarded as precious medicinal plant species that are infrequently found in various locations in Pakistan. In terms of biological forms, most plantspecies (63 %) were herbs, while trailers were the least reported (2 %). The most frequently used plant parts were the whole plant (36 records) followed by seeds (33 records) while least used part was the latex. The most dominant mode of utilization was powder (47 records) followed by powder (28) and paste (12) while least modes ofutilization are juice and eaten in raw form. In quantitative analysis, UV ranges from
0.025 to 0.135 where highest values were reported for *Solanum incanum* (0.1) followed by *Aerva javania* (0.105), *Citrullus colocynthis* and *Cleome viscosa* (0.102), while lowest value was reported for *Convolvulus arvensis* (0.0225). The RFC ranges from 0.125 to 0.195 where highest value was reported for *Senna italica* (RFC = 0.195) followed by *Solanum surattense* (0.187) and *Fagonia bruguieri* (0.179). The lowest RFC was accounted for *Amaranthus viridis* (RFC = 0.125). Findings of presentstudy reveal those medicinal plants of study area are major sources of ethnoveterinary medicine for treating various commonly occurring disorders of livestock.

Plate 14: A) *Acacia senegal* (L.) Willd. B) *Acacia nilotica* (L.) Delile

Plate 15: A) *Achyranthes aspera* L. B) *Aerva javanica* (Burm.f.) Juss.ex Schult

Plate 16: A) *Amaranthus virdis* L. B) *Arthrocnemum macrostachyum* (Moric.) K.Koch

Plate 17: A) *Asphodelus enuifolius* Cav. B) *Azadirachta indica* A. Juss.

Plate 18: A) *Barleria prionitis* L. B) *Barleria acanthoides* Vahl

Plate 19: A) *Blepharis sindica* Stocks ex T. Anderson B) *Boerhavia procumbens* Banks ex Roxb.

Plate 20: A) *Calotropis procera* (Aiton) Dryand B) *Capparis spinosa* L.

Plate 21: A) *Capparis decidua* (Forssk.) Edgew. B) *Chenopodium murale* L.

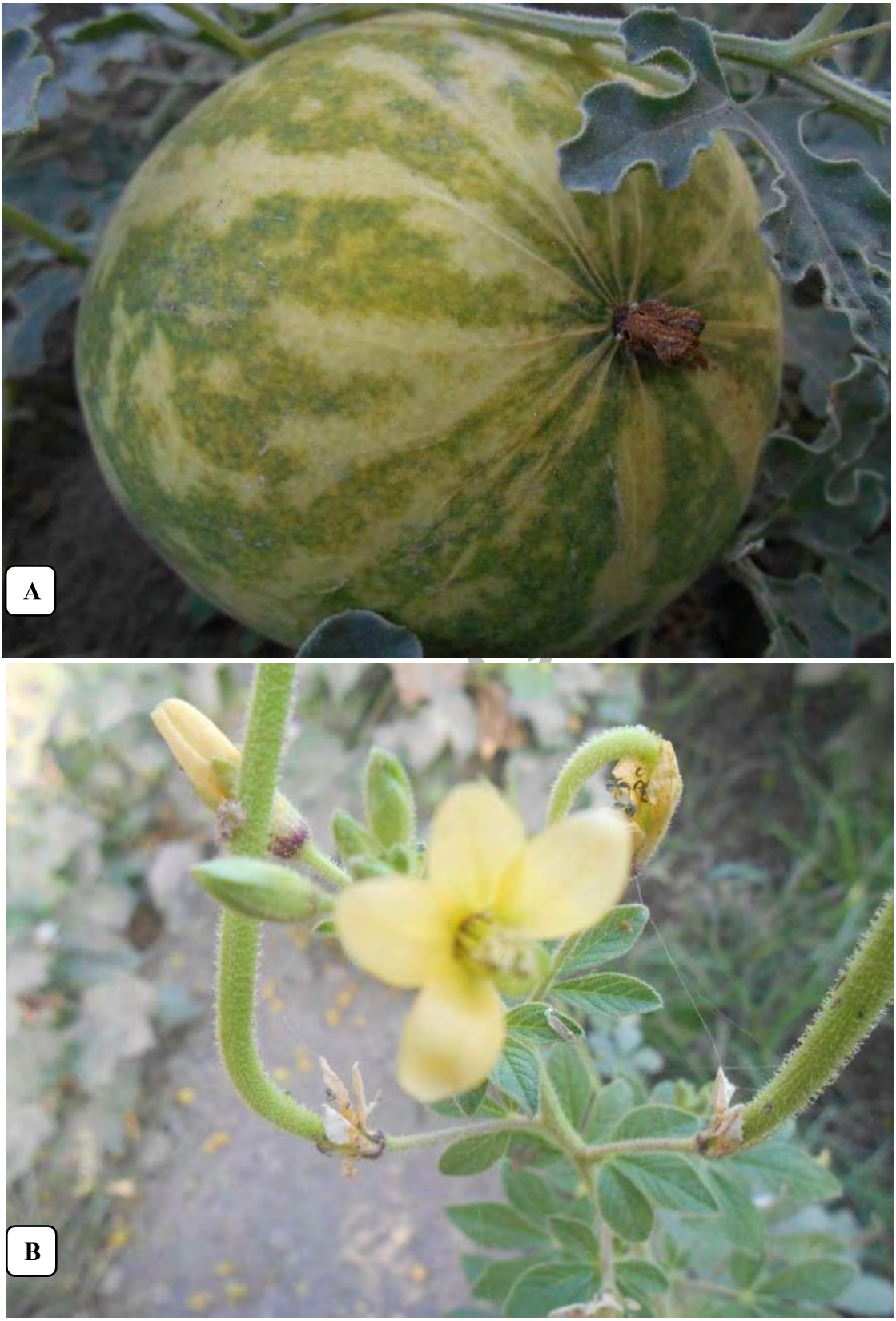


Plate 22: A) *Citrullus colocynthis* (L.) Schrad B) *Cleome viscosa* L.

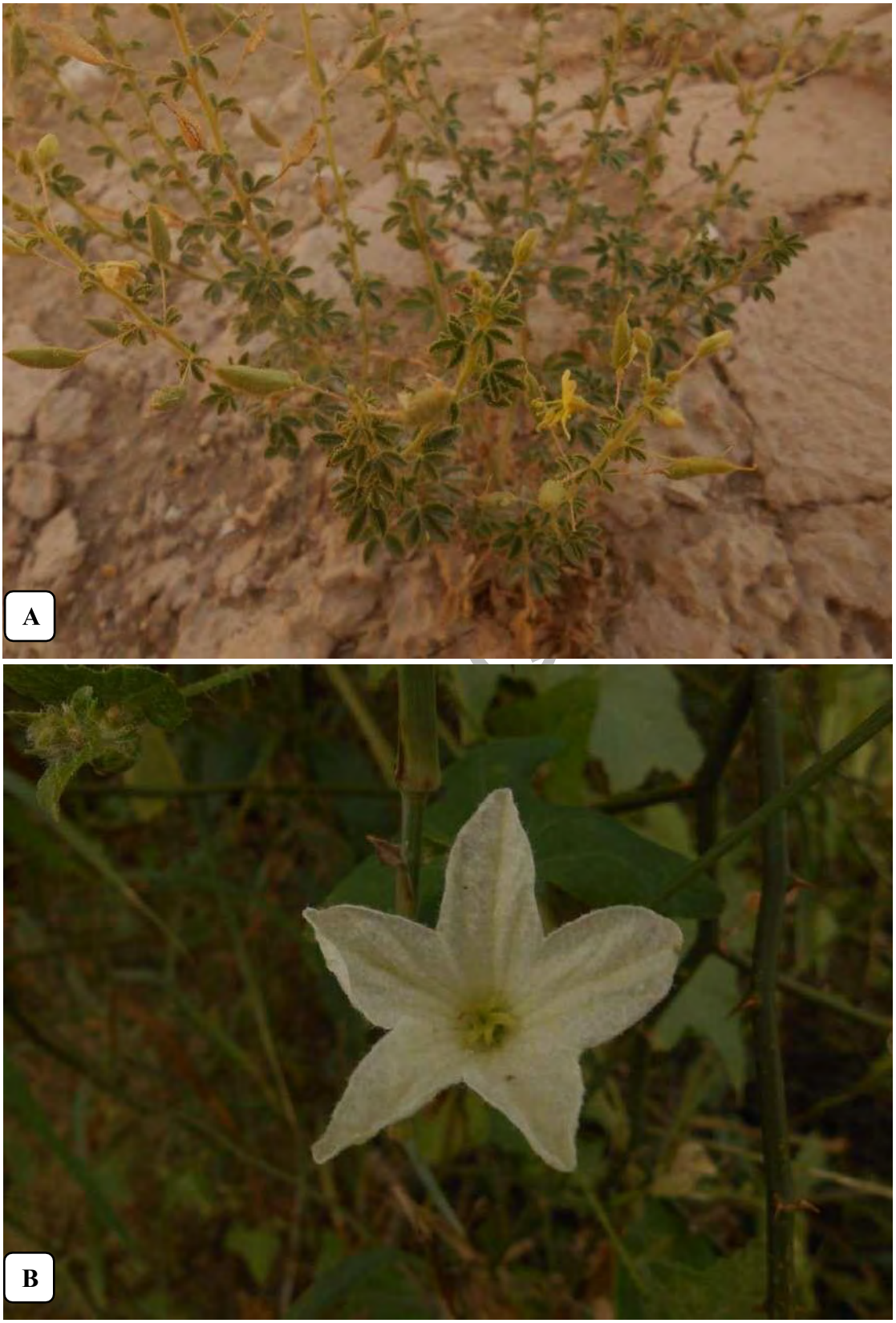


Plate 23: A) *Cleome brachycarpa* (Forssk.) Vahl ex DC. **B)** *Coccinia grandis* (L.) Voigt

Plate 24: A) *Convolvulus arvensis* L. B) *Corchorus depressus* (L.) Stocks

Plate 25: A) *Cressa Cretica* L. B) *Crotolaria burhia* Buch-Ham

Plate 26: A) *Cyamopsis tetragonoloba* (L.) Taub. B) *Cymbopogon jawarancusa* (Jones) Schult.

Plate 27: A) *Digera Muricata*(L.) Mart. B) *Fagonia bruguieri* DC.

Plate 28: A) *Fumaria indica* (Hausskn.) Pugsley B) *Heliotropium bacciferum* Forssk.

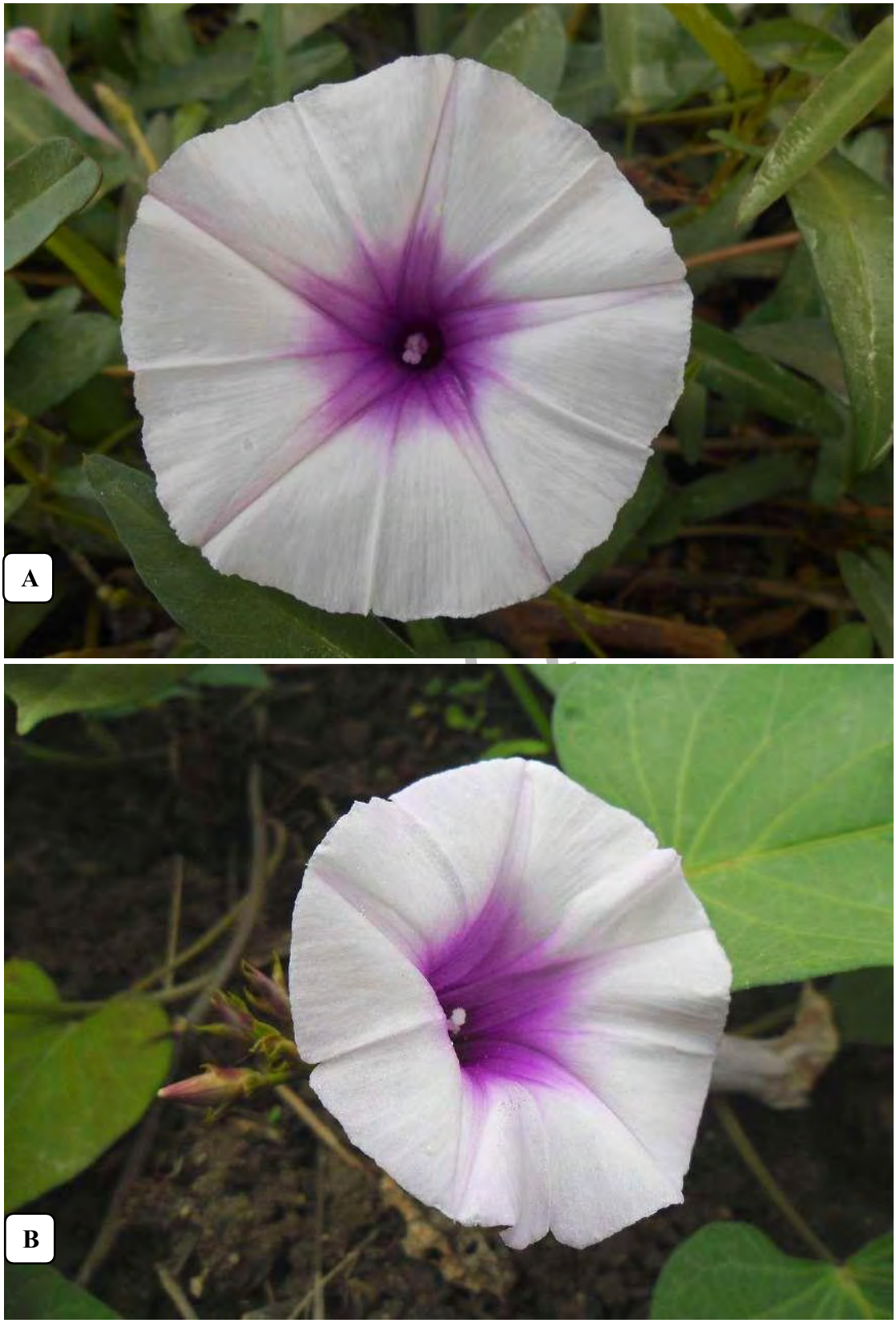


Plate 29: A) *Ipomoea aquatica Forsskål* B) *Ipomoea batatas* (L.) Lam.

Plate 30: A) *Lathyrus aphaca* L.B) *Leptadenia pyrotechnica* (Forssk.) Decne.

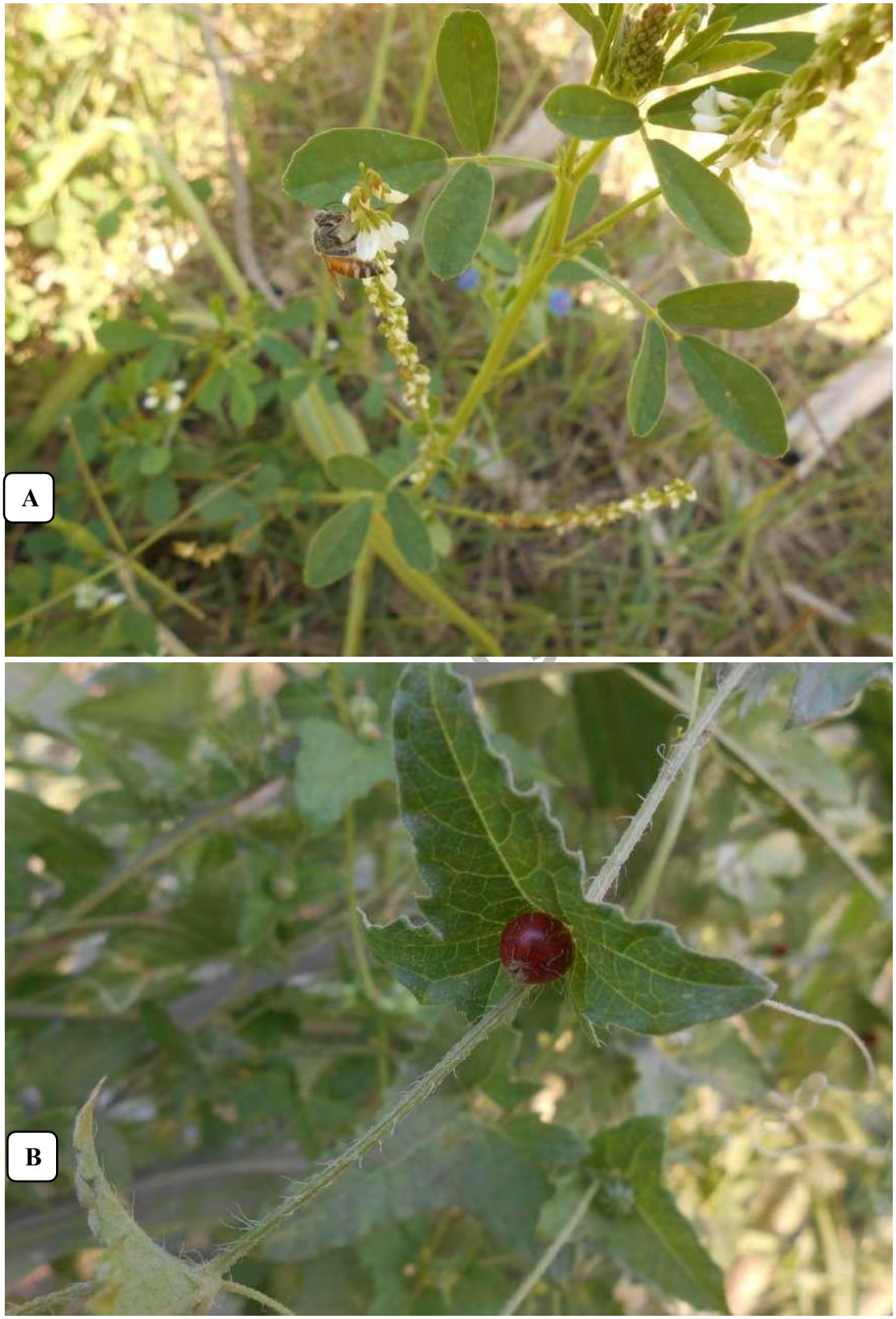


Plate 31: A) *Melilotus alba Ledeb* . B) *Mukia maderaspatana*(L.) M. J.Roemer.

Plate 32: A) *Nelumbo nucifera* Gaertn. B) *Opuntia dillenii* (Ker Gawl.) Haw

Plate 33: A) *Oxystelma esculentum* R. Br B) *Phalaris minor* Retz. L.

Plate 34: A) *Prosopis cineraria* (L.) Druce B) *Pulicaria boissieri* Hook. f.

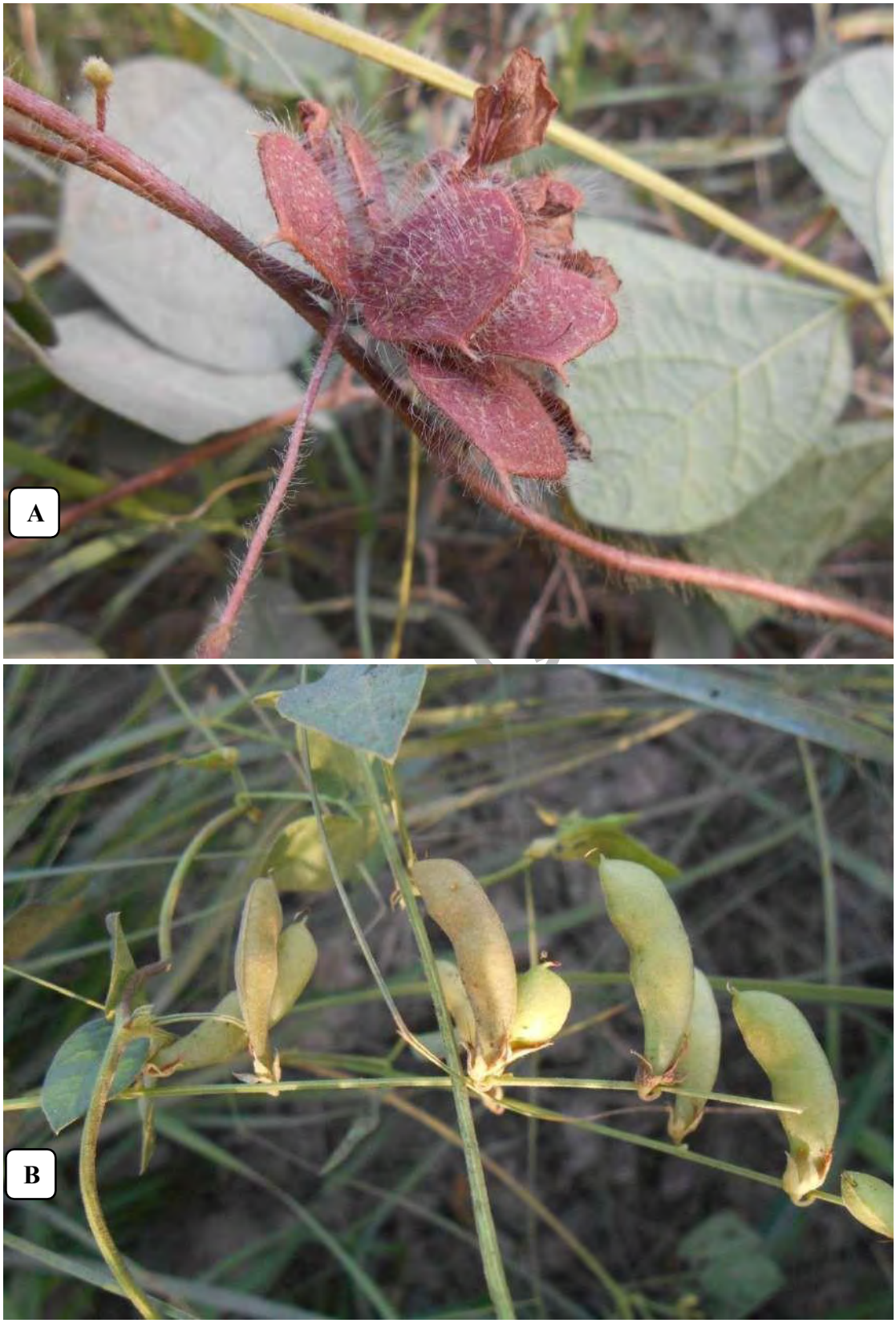


Plate 35: A) *Rhynchosia acuminatifolia* Makino B) *Rhynchosia capitata* (Roth.) DC.

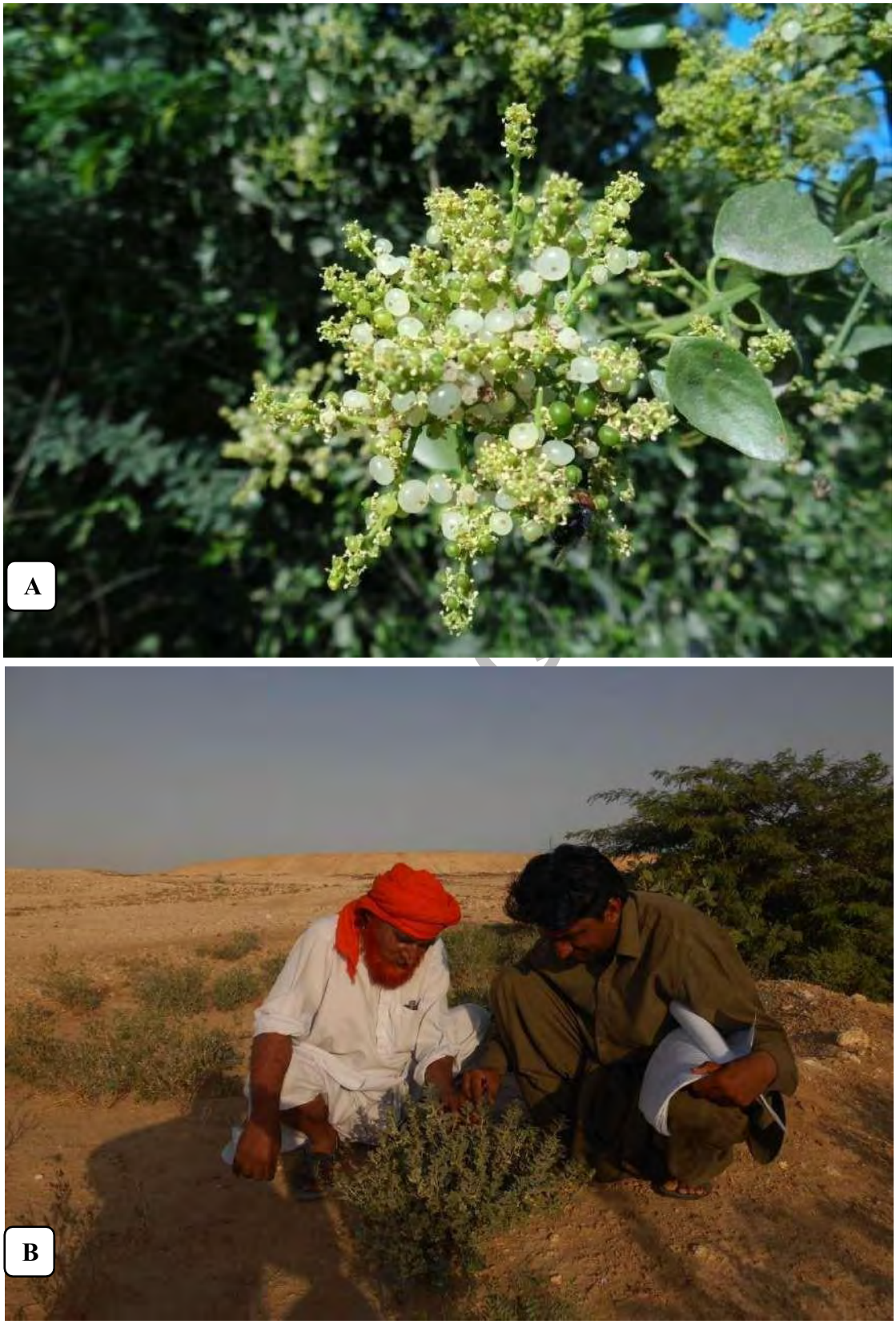


Plate 36:A) B) *Salvadora alii* Rajput & Syeda B) *Schweunfurthia papilionaceae*

Plate 37:A) *Senna italica* Mill. B) *Solanum surattense* Burm. f.

Plate 38: A) *Solanum incanum* L. B) *Tamarix aphylla* (L.) Karst

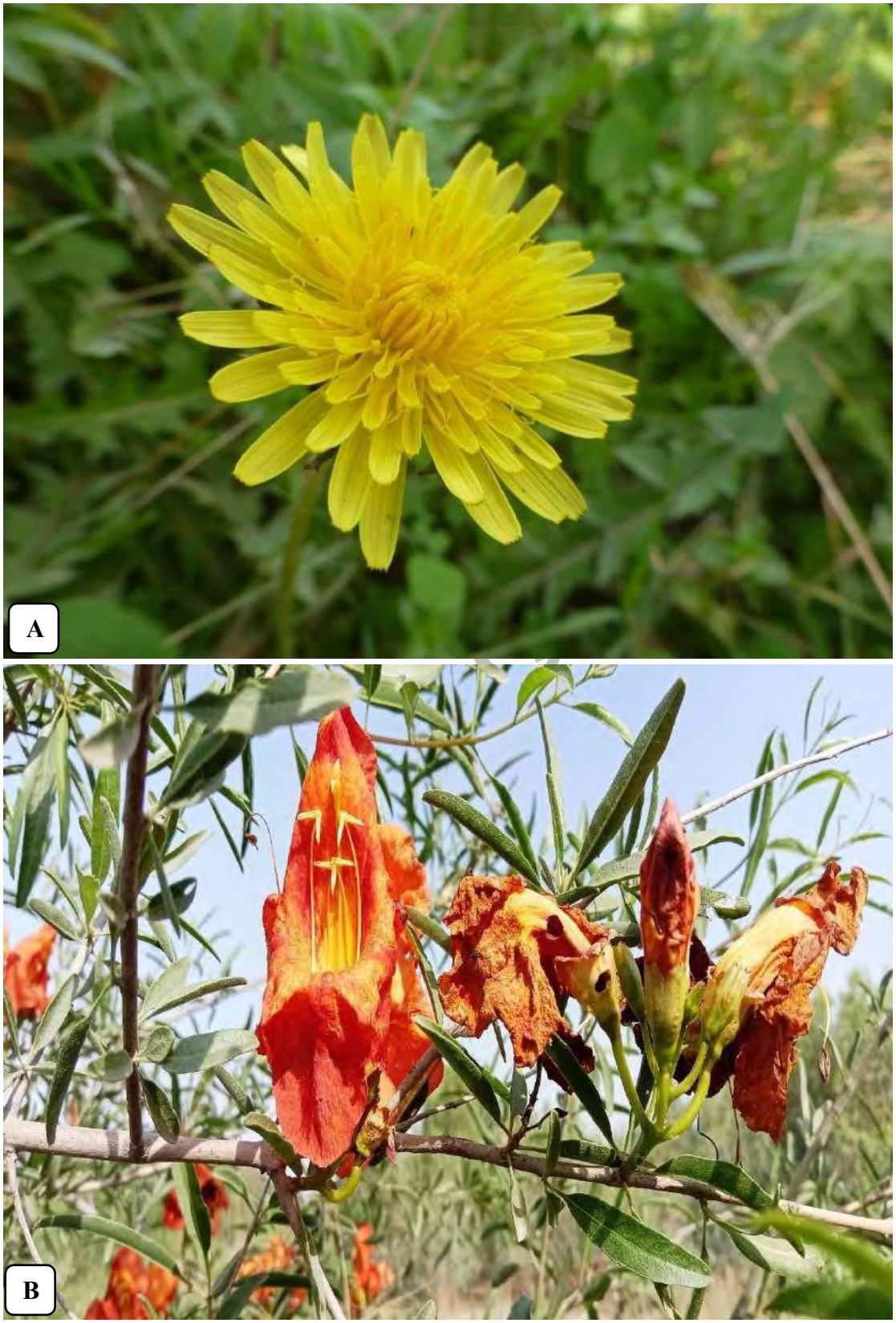


Plate 39: A) *Taraxicum officnarium* Linn. B) *Tecomella undulata* (Sm.) Seem

Plate 40: A) *Tribulus terrestris* L. B) *Ziziphus mauritiana* Lam.

Section III

Ethnobotany of Medicinal plant species used in Treatment of Human Diseases

3.3.1 Demographic Data of Informants in the Deserts of Southern Sindh

During the field surveys, total 256 informants were interviewed, including 36 traditional health practitioners and 220 local informants. Majority of informants were males (77%) while females were 23%. The numbers of female informants are less in number as they are restricted to communicate with strangers and their least interest in giving any information. Large number of informants was in the upper age limit of 40-45 years (25%), followed by less than 20 years age limit (6%), because of limited knowledge of herbal recipes used in indigenous communities. This indicated that indigenous knowledge among young is declining due to fast trend among rural communities whereby most of the young aged people did not rely on traditional medicine (Hong et al., 2015). However, the present study concluded that the old, aged informants showed more interest during interviews.

In educational perspective, the informants were mostly Illiterate (29%), while formal educations of 5 years (23%) were observed. This socioeconomic attribute of research participants was discovered to be consistent with other studies (Paksoy et al., 2016). Much research has indicated that traditional plant knowledge is more prevalent in less educated populations (Wodah and Asase, 2012). Other demographic information about the study participants' occupations, informant categories, and traditional health practitioner experiences were also collected. Among interviewed informants, the Dhatki (55%), Sindhi (25%) speaking ethnic tribes were more prevalent in population as compared to others speaking mother tongues. Dhatki or was originally spoken by knowledge informants whereas mostly informant told the local names of reported plant species in Dhatki. This showed that effect of Dhatki culture over other tribes resulting in transmission of ethnomedicinal knowledge of plants from one tribe to others.(Yaseen et al., 2015) also cited that main language spoken in the Thar Desert was Dhatki. Accordingto (Leonti, 2013), the transmission of ethnobotanical medicinal knowledge is enhanced because of current continuous intercultural contacts between local and global communities.

Table 7: Demographic information of Informants in the Deserts of Southern Sindh

S.No	Variables	Participants	Number	Percentage
1.	Categories	THPs	36	14
		Local People	220	86
	Gender	Male	198	77
		Female	58	23
2.	Age	40-50	65	25
		50-60	41	16
		60-70	35	14
		70-80	60	23
		80-90	35	14
		90-100	20	8
3.	Education	Illiterate	75	29
		05 years	60	23
		08 years	25	10
		10 years	30	12
		12 years	29	11
		Undergraduate	17	7
		Graduated	20	8
4.	THPS experience	Less than 2 years	2	6
		2 to 5 years	12	33
		5 to 10 years	7	19
		10 to 15 years	11	31
		15 to 20 years	4	11
5.	Mother Language	Gujrati	35	14
		Dhatki/ Maharwaari	140	55
		Sindhi	65	25
		Urdu	16	6

3.3.2 Diversity of Medicinal Plants Used in the Human Healthcare in Deserts of Southern Sindh

In total, 79 ethnomedicinal plant species from 48 families (Figure 6) were recorded from diverse groups in the deserts of Southern Sindh, together with their ethnomedicinal applications, plant parts used, ways of usage, and herbal recipes. The detailed information including taxonomic name, local names, part used, mode of

preparations, ethnomedicinal uses and frequency of citation (FC) count is presented in table 8.

Among the reported families, highly reported families based on the number of species reported were: Asteraceae (09 species), Fabaceae (08), Solanaceae (06), Boraginaceae (05), Poaceae (04), Casesapiniaceae, Chenopodiaceae and Euphorbiaceae (03 species each) as mentioned in figure 6. The dominance of the species of these families was indicated by their frequent use in traditional ethnomedicine, which are easilyavailable or preferred over other species of medicinal plants. The plant species belong to above commonly cited families have been reported in many earlier studies for their medicinal importance indicating the reason behind frequent reports of species (Wodah and Asase, 2012). Leguminosae has been noted as a highly cited family in many earlier research due to the diversity of bean species found in study regions (Kffuri et al., 2016; Yazbek et al., 2016). Another study (Bibi et al., 2014; Ghorbani et al., 2011) identified Asteraceae as one of the most frequently used families, while another study (Shuaib et al., 2019) reported Solanaceae as the most frequently reported family in ethnobotanical assessment. People in each area favor plant species that are readily available, accordingto (Stepp and Moerman, 2001).

According to our findings, species belonging to the above-mentioned families were readily available. Legumes are a substantial source of protein, dietary fiber, carbs, and dietary minerals in the deserts of Southern Sindh, according to locals. According to some of the respondents, including legumes in a plant-based diet on a regular basis can help to reduce the prevalence or risk of developing metabolic syndrome. While thequality of the supporting evidence is uncertain, there is evidence that include a portion of pulses (about one cup daily) in one's diet can help decrease blood pressure and LDL cholesterol levels.

In life forms, most of the reported plant species were herbs (67%), followed by shrubs (16%), trees (10%) while climbers (4%) and trailers (3%) are least collected plant species as summarized in figure 7. The dominant use of herbaceous form might be the

easy availability and collection of these plants' species. Herbs are frequently used in traditional medicine because to their ease of availability, proximity to humanenvironments, and diversity of bioactive compounds, according to various studies (Ullah et al., 2018; Voeks and Leony, 2004). Baydoun et al. (2015) found that herbs weredominantly utilized in herbal production and providing fundamental human various ailments and therapeutic indications due to their medicinal properties. Herbs have a long history in traditional medicine due to their high success rate in healing chronic diseases, according to Panickar (2013). Ouelbani et al., (2016) similarly concluded that the prevalence of growth types is always dependent on the nature of plant diversity, climate, and, most crucially, the geographic location of the place. The frequent reports of herbaceous plant species in the current study might be attributed to the vast diversity surrounding of indigenous communities, and such arguments are validated by otherstudies (Uniyal et al., 2006). Herbs' dominance in medicinal flora may be because they are more easily available than trees and bushes in adjacent regions (Lulekal et al., 2013). Bhatia et al., (2014) also documented the prevalence of herbs in their respective medicinal floras. Many explanations for the frequent use of herbs in traditional medicine have been mentioned in the literature. Herbal recipes may be created simply from herbs, according to Mesfin et al., (2009) and Lulekal et al., (2013). While according Ayyanar and Ignacimuthu, (2005) and Tabuti et al. (2010), Herbs might readily thrive along roadsides, wastelands, home gardens, farms, and in the wild. To the best of our knowledge, the reason herbs are most commonly employed in traditional medicine is related to cultural beliefs about the procedures used for preparation forms and extraction processes.

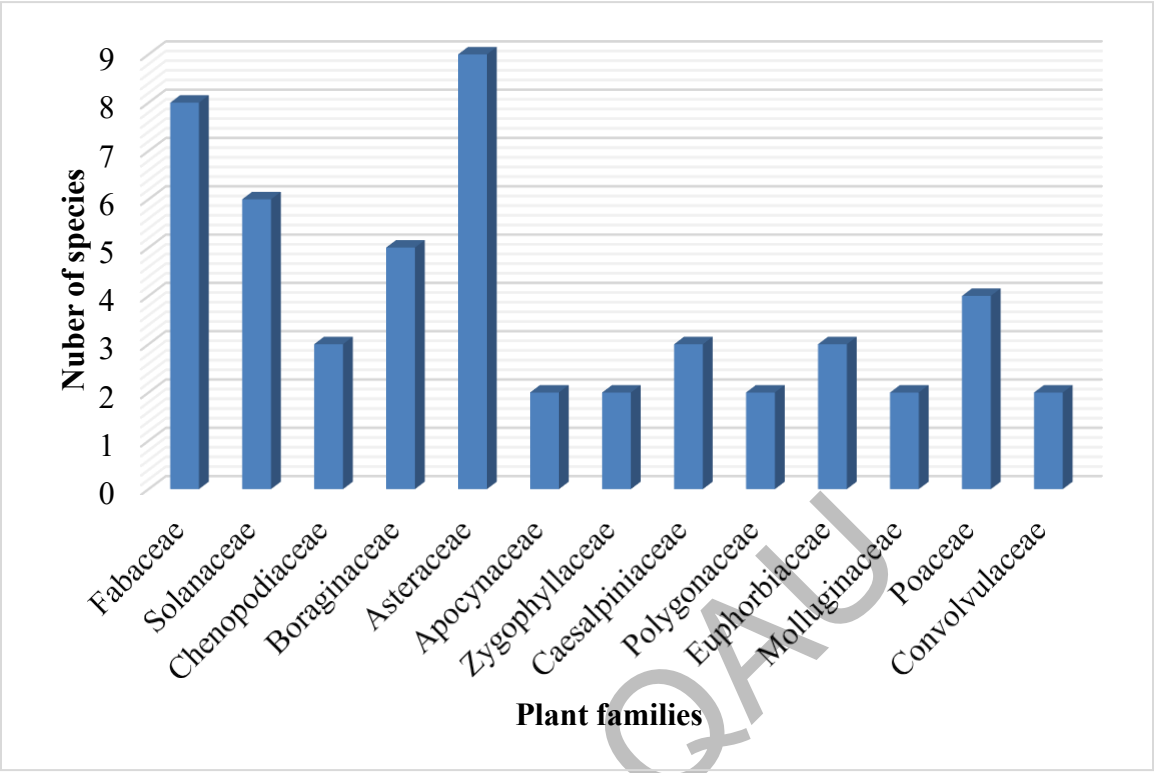


Figure 6: Graphical representation of dominant families

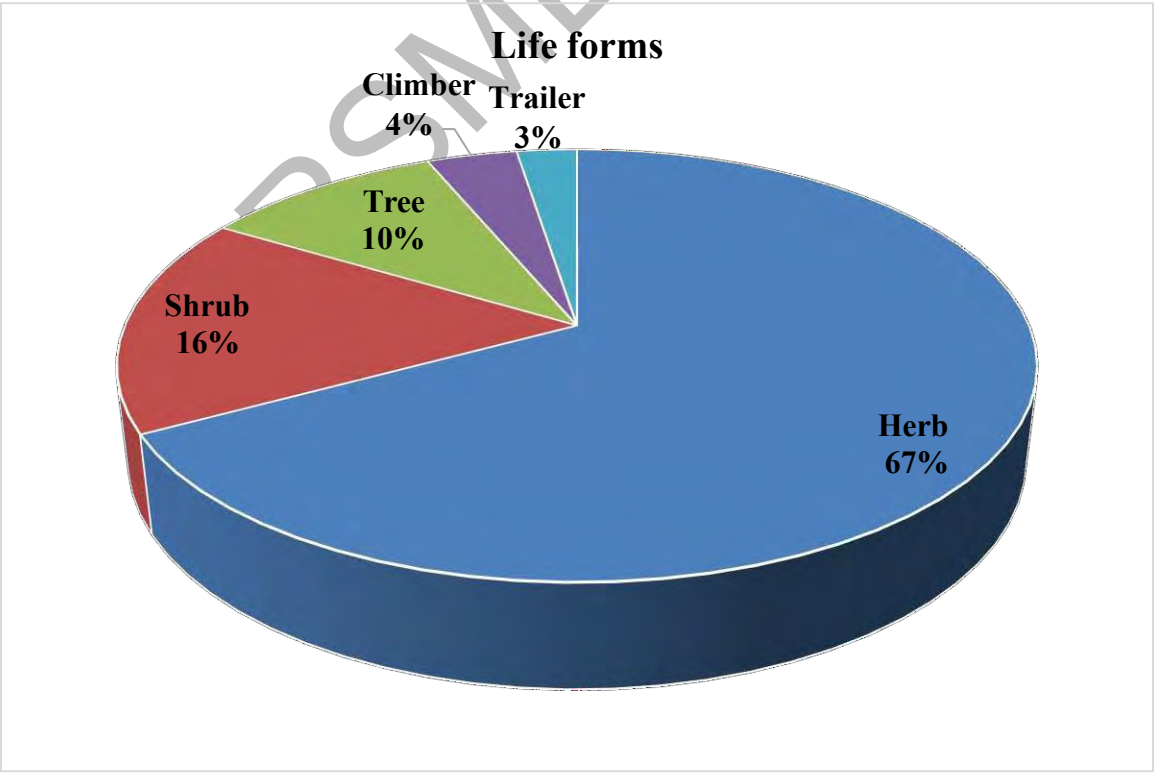


Figure 7: Life form classification of ethnomedicinal plants

3.3.3 Plant Part used in the Treatment Human Diseases

The leaves (23%) were the predominantly used plant parts for preparation of herbal recipes, followed by flowers (22 %), seeds (21 %) and whole plant (16 %) while least reported parts used were stem (4%), barks (3%) and other parts including rhizome, latex, gum etc. (2%) (Figure 8). In literature, traditional healers often use herbs and trees most commonly as medicine because of their easy availability (Parthiban et al., 2016).On the other hand, the result of this study was not in agreement with the findings of Maneenoon et al., (2015) which reported that underground parts and whole plant were themost used parts. The predominance of leaves in herbal therapies may be attributed totheir abundance, their richness in secondary metabolites and a collection of leaves would be much easier and sustainable than that of roots or flowers (Benarba, 2016). The use of leaves to cure illnesses is since leaves are the primary photosynthetic organs and are among the components that are reasonably easy to reach and available all year (Bi et al., 2008). Leaves have also been found to be the most utilized plant component by Kumar and Bhagat (2012), Bhushan and Kumar (2013), and Rao et al., (2015). Many informants in this study claimed that leaves are the most important component and are widely usedin local communities.

According to (Komoreng et al., 2017) barks are least utilized in traditional medicine dues to their most damaging consequences on survival of plants. People in the study region use leaves for production of various herbal remedies because leaves can be harvested simply without any extra hard work as opposed to underground portions like rhizome and roots. Ong et al., (2018) previously reported high preference for leaves is most likely due to their availability, as they are frequently the most visible and possibly the most frequent aboveground component in this ecoregion. In terms of conservation, using leaves in herbal medicines is a more sustainable approach, whereas extracting roots(which sometimes necessitates uprooting) might lead to plant mortality. Furthermore, leaves have been scientifically proved to be more photo synthetically active organs than any other component of the plant (Giday et al., 2009; Mukheriee and Wahile, 2006). Although leaves are widely recorded in ethnobotanical research, seeds are described as

the most regularly utilized part in various studies (Asadbeigi et al., 2014; Ishtiaq et al., 2006).

3.3.4 Mode of Utilization in the Treatment of Human Diseases

In present study, Powder was predominantly reported with 35% reports, followed by decoction (34 %) and juice (13 %) as mentioned in figure 09. Powder is made by crushing and grinding of dried plant parts while decoction can be prepared by putting plant part in boiling water until quantity of water is decreased to half or requisite. Powderis the preferred form of use by the majority of THPs. Powders have a longer shelf life in herbal clinics than decoctions, which degrade faster, confirming their widespread use in our study (Gupta et al., 2012). According to Buwa (2012), the most common method of utilization was powdered plant material. Traditional healers believed that medications made from plant powders were more effective because the powder form allows for more bioactive components to be extracted (Tchicaillat-Landou et al., 2018).

Many researcher (Canal et al., 2000; Chen et al., 2012; Kamatou et al., 2008) have reported the use of decoction for a variety of reasons. One of the most frequently stated reasons is that boiling activates the therapeutic properties of specific plant metabolites, whereas boiling may cause synergism for multiple plant species utilized in a decoction (Obolskiy et al., 2009 The dominance of powder form in this study reflects a cultural trend in mode of consumption limited to arid locations, with THPs preferring powder as a common way of utilization. Powders have a longer shelf life in herbal clinics than decoctions, which can degrade faster, justifying the use of powders in this investigation. Traditional healers prefer oral intake of herbals since it is simple to administer and does not require the use of any complicated processes (Prashanth et al., 2001; Poonam and Singh, 2009). Due to its ease of preparation by mixing with water or tea, decoction is the most utilized method for preparing indigenous herbal therapies (Khan et al., 2011). Many studies have reported on decoctions for a variety of reasons (Asase and Yohonu, 2016; Awan et al., 2021). Boiling plant material for a minimum of one hour and a maximum of two hours was the standard method for making decoctions.

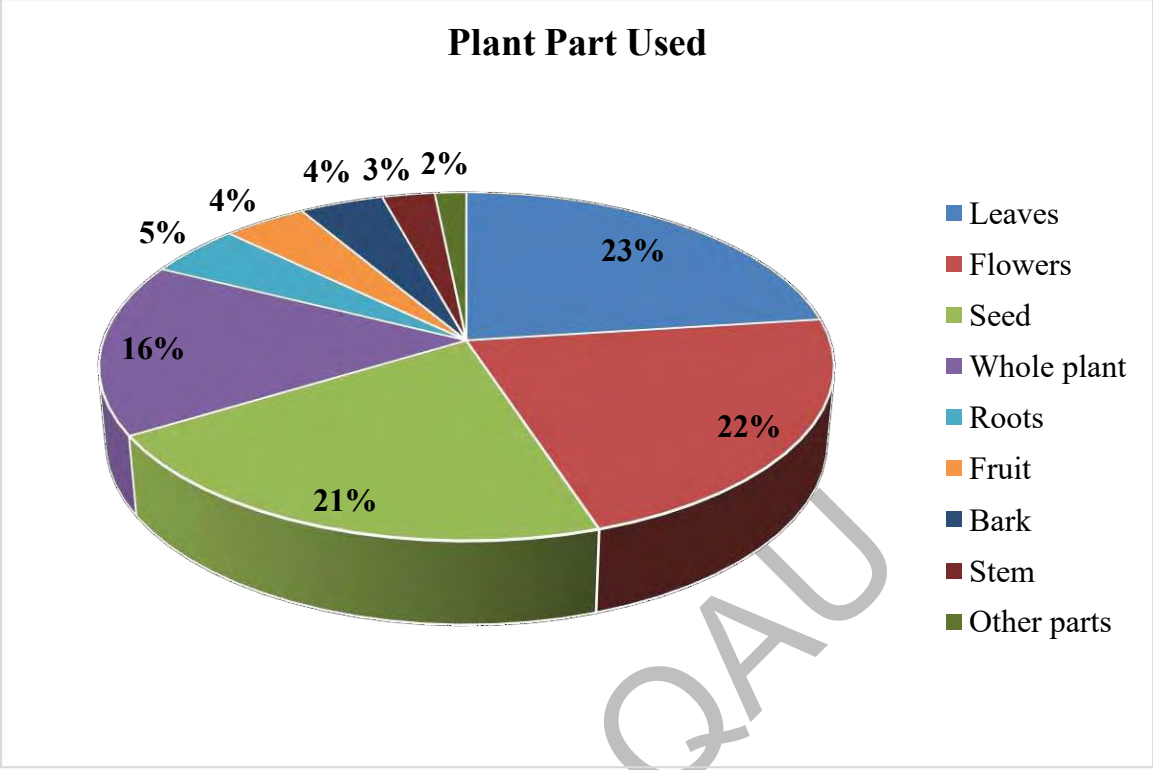


Figure 8: Plant part used in the treatment of Human diseases

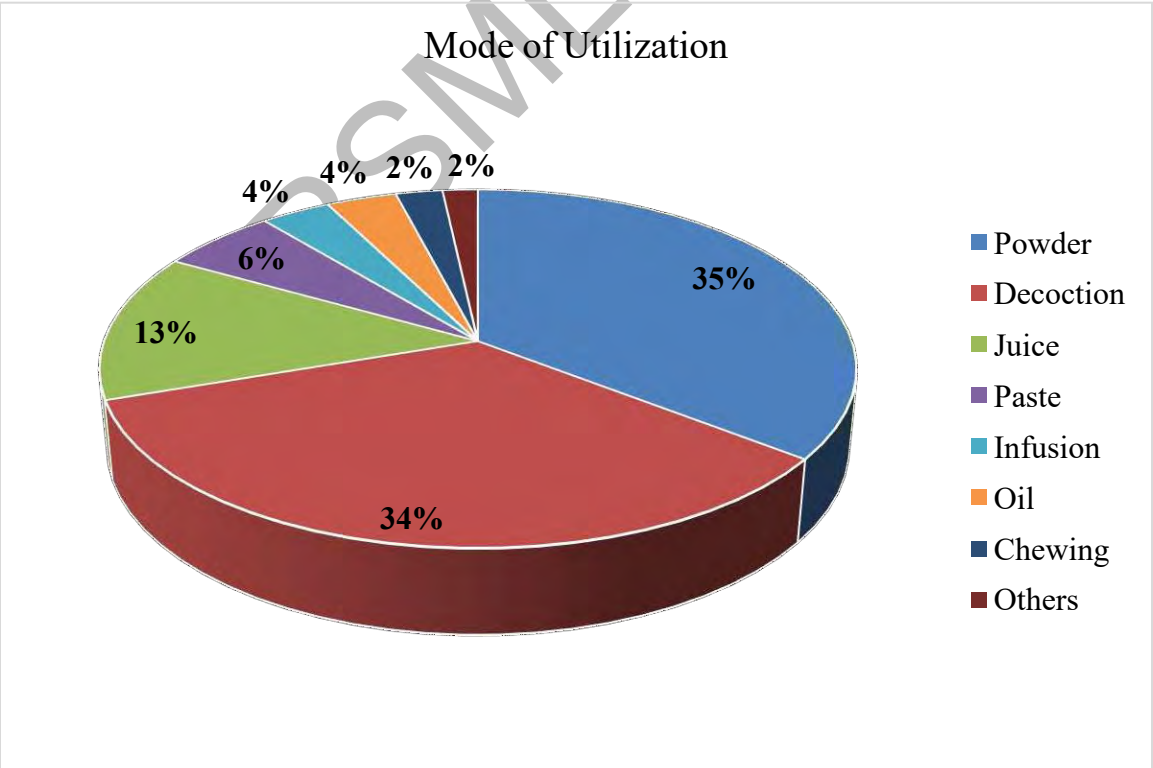


Figure 9: Mode of utilization for the treatment of Human diseases

Table 8: List of Plants and their ethnobotanical uses for the treatment of Human diseases in the Deserts of Southern Sindh

S. No	Scientific name	Local name	Part used	Mode of utilization	Disease treated	FC[*1]	UR[*2]	RFC[*3]	UV[*4]
1.	*Acacia Senegal* (L.) Willd.	Babari	Leaves, Seed Flower, Bark, Gum	Decoction, Powder	Throat, Diarrhea, Cough, Sexual tonic	58	4	0.311	0.1
2.	*Albizia lebbeck* (L.) Benth.	Sarah	Flower, Seed, Leaves, Bark	Decoction, Juice, Infusion	Dysentery, Bloating, Urinary disorder, Eye infection	43	4	0.231	0.060
3.	*Alhagi maurorum* Auct. non Medik.	Kandero	Leaves, Flower, Seed	Decoction, Powder	Headache, Joint pain, Chest pain, Kidney stone, Gastonia	82	5	0.440	0.04
4.	*Anticharis glandulosa* Asch.	Gamesh	Whole plant, Leaves	Powder, Decoction, Infusion	Vermifuge, Diabetes, Menstrual pain, Blood purifier, Pimples	69	5	0.370	0.068
5.	*Arnebia decumbens* (Vent.) Coss. &Kralik	Kharieboti	Leaves, Root, Flower	Decoction, Powder, Tincture	Joint disorder, Pneumonia Wound healing	44	3	0.236	0.042
6.	*Avena sativa* L.	Javi	Whole plant, Seeds	Powder	Diarrhea, Muscular disorder	47	2	0.252	0.065
7.	*Azadirachta indica*A. Juss.	Neem	Leaves, Seeds, Branches, Flower	Decoction, Powder	Swelling body part, Fever, Skin spots, Toothache, Muscular disorder	76	5	0.408	0.034

8.	*Calligonum polygonoides* L.	Fog	Leaves, Flower, Root	Decoction, Powder, Paste, Poultice	Bloating cramps, Urinary disorder, Dandruff on skin, Snakebite, Typhoid, Eczema	84	8	0.451	0.035
9.	*Calotropis gigantea* (L.) Dryand.	Aaki	Leaves, Flower	Decoction, Powder, Latex	Bee sting, Tuberculosis, Dry cough	85	3	0.456	0.055
10.	*Celosia argentea* L.	Salaro	Husk, Flower, Leaves	Decoction, Powder	Burling of vision, High blood pressure, Spleen diseases, Hypertension	52	4	0.279	0.035
11.	*Cenchrus biflorus* Roxb. Bhurat	Dhamangaah	Whole plant, Seed	Powder, Decoction	Stomach ulcer Cough	56	2	0.301	0.051
12.	*Chenopodium album* L.	Chill	Leaves, Seeds, Root	Juice, Oil, Powder, Decoction	Kidney stone, Thorax infection, Dyspepsia	70	3	0.376	0.065
13.	*Chenopodium murale* L.	Jhalah	Whole plant, Seeds, Leaves	Decoction, Juice	Hair loss, Urinary disorder, Fever	46	3	0.247	0.046
14.	*Cistanche tubulosa* (Schenk) Wight	Jogero	Root, Aerial parts	Juice, Powder, Decoction	Sexual tonic, Tetanus, Blindness, Dysentery, Pregnancy complication	82	13	0.440	0.047
15.	*Citrullus lanatus* (Thunb.) Matsum. &Nakai	Shahieen	Juice, Fruit, Flower	Juice, Powder	Skin glow, Weakness of body, Blood purifier, Jaundice	84	4	0.451	0.035

16.	*Cocculus hirsutus* (L.) W.Theob.	Vasanvel	Leaves, Flower, Stem	Juice, Decoction, Extract	Ovarian disorder, Urethral discharge, Chronic cough, Lupus	73	4	0.392	0.027
17.	*Convolvulus prostratus* Forssk.	Latiualbhatar	Whole plant, Seeds	Decoction, Powder, Juice	Mammary gland disorder, Sexual tonic, icterus	54	3	0.290	0.046
18.	*Crotalaria burhia* Benth	Feer,Makhanboo	Whole plant	Decoction, Powder	Wound, Hydrophobia, Kidney infection, Rheumatism, Cancer, Diarrhea, Typhoid, Gout, Swellings, Nausea, Placenta delivery	51	11	0.274	0.075
19.	*Crotalaria medicaginea* Lam.	Andari	Whole plant, Seeds, Leaves	Decoction, Raw	Chest infection, Joint pain, Malaria, Sexual tonic, Eye ulcer	66	5	0.354	0.024
20.	*Cuscuta reflexa* Roxb.	Bapari	Whole Plant	Juice, Powder, Decoction	Jaundice, Enhance urination, Hepatitis	37	3	0.198	0.042
21.	*Dactyloctenium aegyptium* (L.)Willd	Mandari	Whole plant, Seeds	Powder, Decoction, Extract	Muscular dystrophy, Mammary gland disorder	68	2	0.365	0.096
22.	*Datura innoxia* Mill.	Chariodatro	Leaves, Seeds, Root	Paste, Oil, Powder	Asthma, Muscular disorder, Paralysis, Athlete foot, Skin allergy	52	5	0.279	0.064
23.	*Diplachne fusca* (L.) Stapf	Kalari	Whole plant,	Decoction,	Diarrhea, Stomach	48	3	0.258	0.068

			Seed,	Powder	ulcer, Joint pain				
24.	*Enicostemma hyssopifolium* (Willd.) Verdoon	Chota-Chirayat	Whole plant, Flower, Root	Powder, Decoction	Hernia, swelling, Menses disorder, Abdominal pain	90	3	0.483	0.047
25.	*Eucalyptus globulus* Labill.	Bedamushk	Flower, Leaves	Powder, Decoction	Cough, Fever, joint pain	68	3	0.365	0.052
26.	*Euphorbia granulata* Forssk.	Pat charo	Whole plant, Seed	Powder, Decoction, Oil	Intestinal warm, Snake bite, Jaundice	57	3	0.306	0.15
27.	*Euphorbia hirta* L.	Dhedi	Whole Plant, Flower, Seed, Stem, Root	Decoction, Latex, Powder	Bronchitis Heart, Respiration, Worm removal, Asthma, Cough, Flow of milk in women, Gonorrhea, Vomiting	60	9	0.322	0.044
28.	*Fagonia cretica* L.	Acho Dramahio	Whole plant	Powder, Decoction, Raw	Brain tumor, Kidney stone, Cancer	89	4	0.478	0.140
29.	*Glinus lotoides* L.	Tar daani	Whole plant, Flower, Leaves	Decoction, Powder, Infusion	Blood purifier, Purgative, Blisters on face	94	3	0.505	0.027
30.	*Gnaphalium polycaulon* Pers.	Saagi	Flower, Seeds	Powder	Malaria, Skeleton disorder	74	2	0.397	0.104
31.	*Grangea maderaspatana* (L.) Poir.	AfsantinMustaru	Leaves, Whole plant	Infusion, Decoction	Menorrhea, Pain killer, stomach problems, Otalgia, Nausea	48	5	0.258	0.032
32.	*Haloxylon stocksii* (Boiss.) Benth. & Hook. f.	Lasolarano	Whole plant, Stem, Seed	Powder, Decoction	Menses Pain, Urinary disorder, Spleen	93	3	0.5	0.035

					enlargement				
33.	*Heliotropium bacciferum* Forsk.	Pholi	Leaves, Flower	Decoction, Paste	Asthma, Wound, Bladder control problems	85	3	0.456	0.022
34.	*Heliotropium crispum* Desf.	Ghuli	Whole plant, Flower, Leaves	Juice, Powder, Juice	Scorpion venom, Eye redness	90	2	0.483	0.054
35.	*Heliotropium europaeum* L.	Haathisondi	Leaves, Flower, Seed	Decoction, Paste	Renal colic, Wound, Skin spots	55	3	0.295	0.023
36.	*Heliotropium strigosum* Willd.	Phulii	Whole plant, Leaves	Juice, Powder, Poultice	Nose infection, Insect bite	86	2	0.462	0.025
37.	*Hibiscus scindicus* Stocks	Gulashue	Flower	Juice	Eye infection	40	1	0.215	0.035
38.	*Indigofera cordifolia* Roth.	Vakar	Flower, Seed	Decoction, Juice	Insect sting, Constipation	56	2	0.301	0.022
39.	*Iphiona grantioides* (Boiss.) Anderb.	Ghotkhwar	Aerial part	Powder, Decoction	Anticancer, Tooth decay	87	2	0.467	0.031
40.	*Ipomoea cairica* (L.) Sweet	Gholii	Flower, Seeds	Powder	Nerve disorder, Sexual tonic	63	2	0.338	0.028
41.	*Launaea procumbens* (Roxb.) Ramayya & Rajagopal	Bhatir	Whole plant, Root	Juice, Powder	Rheumatism, Skin allergy, Kidney dysfunction	70	3	0.376	0.027
42.	*Lawsonia inermis* L.	Mehndi	Seeds, Leaves	Decoction, Powder	Stomach ulcer, foot burning	74	2	0.397	0.037
43.	*Lepidium sativum* L.	Arhyo	Leaves, Seeds	Oil Powder	Menstruation disorder, Constipation, Diarrhea	80	3	0.430	0.024

44.	*Medicago lupulina* L.	Saatali	Whole Plant, Flower	Powder, Decoction	Jaundice, Constipation, Body pain	12	3	0.064	0.066
45.	*Melilotus albus* Medik.	Achi sinjhe	Whole plant, Leaves, Flower	Paste, Decoction	Cough, Stomach ulcer, Jaundice	45	3	0.241	0.037
46.	*Mollugo cerviana* (L.) Ser.	Hazardani	Whole plant, Flower, Seed, Root	Powder, Decoction	Antiseptic, Diaphoretic, Jaundice, Gastralgia, Rheumatism	14	6	0.075	0.076
47.	*Moringa oleifera* Lam.	Sohanghro	Flower, Bark, Leaves	Decoction, Powder	Paralysis, Aphrodisiac, Urinary disorder, Face spot	20	4	0.107	0.263
48.	*Nelumbo nucifera* Gaertn.	Beah	Rhizome Leaves, Seed, Petals	Cooked, Powder, Decoction, Latex	Hematemesis, Hematuria, Chronic cough, Sexual tonic, Gastritis	19	5	0.102	0.148
49.	*Nerium oleander* L.	Kanargul	Root, Latex, Leaves	Decoction, Powder	Abortion, Skin allergy, Reproductive disorder, Muscular disorder	27	4	0.145	0.095
50.	*Neurada procumbens* L.	Kua dhal,	Whole plant, Seed, Leaves	Juice, Powder	Sexual tonic, Blood pressure, Blockage of veins, Skin diseases, Urinary disorder	63	6	0.338	0.098
51.	*Nicotiana tabacum* L.	Tamak	Whole Plant, Leaves, Flower, Seed	Smoking, Chewing, Powder,	Rabies virus, Snakebite, Swelling, Piles,	52	6	0.279	0.083

				Paste	Nose bleeding Nerve tonic				
52.	*Ochradenus baccatus* Delile	Kirmkush	Whole Plant	Decoction	Wound infection	12	1	0.064	0.178
53.	*Ocimum basilicum* L.	Naaz boo	Seeds, Leaves, Flower, Root	Juice Paste, Oil, Decoction, Powder, Ash	Bladder disorder, Skin diseases, Mouth ulcer, Brain tonic, Ear infection	28	5	0.150	0.081
54.	*Opuntia dillenii* (Ker Gawl.) Haw.	Naangphr	Fruit, Latex	Decoction, Juice	Gonorrhea, Hepatitis, Old Cough, Joint pain	49	4	0.263	0.078
55.	*Parkinsonia aculeata* L.	Arabi Kandi	Leaves, Flower, Seeds	Powder, Juice, Decoction	Diaphoretic, Malaria, Antipyretic	32	3	0.172	0.129
56.	*Peganum harmala* L.	Hermal	Leaves, Stem, Seeds, Flower	Powder Smoke Juice ,Decoction	Abortion, Muscular disorder, Obesity, Jaundice	31	4	0.166	0.4
57.	*Physalis peruviana* L.	Popta	Whole plant, Seeds, Leaves	Powder, Juice, Decoction	Digestive tonic, Blood purifier, Pain killer	18	2	0.096	0.125
58.	*Pithecellobium dulce* (Roxb.) Benth.	Jaleebi	Fruit, Flower, Leaves	Decoction, Powder	Aphrodisiac, Malaria, Gastroenteritis	33	3	0.177	0.227
59.	*Pluchea arguta* Boiss.	Fahar	Leaves, Fruits	Juice, Decoction	Inflammation Piles, Cough, Swelling joint, Scorpion	22	5	0.118	0.107
60.	*Polycarpaea spicata* Wight ex Ran.	Sarangboti	Whole plant, Seed	Powder, Infusion	Cancer, Infertility, Pain in Backbone	28	3	0.150	0.136

61.	*Pulicaria undulata* (L.) C.A.Mey.	Ranbo	Flower, Seeds	Leaves, Seed, Root	Muscular disorder, Cardiovascular disorder	33	2	0.177	0.093
62.	*Rhazya stricta* Decne.	Maswaj	Stem, Bark, Leaves	Whole Plant, Seeds,	Digestive disorder, Skin eruption, Diabetes, Fracture bone, Toothache, Mouth Smell	47	6	0.252	0.157
63.	*Rhynchosia acuminatifolia* Maki no	Farie	Fruit, Seed, Flower	Raw Decoction,	Gastralgia, infertility, Jaundice	19	3	0.102	0.129
64.	*Ricinus communis* L.	Harian pan	Leaves, Seeds, Bark, Flower	Paste, Powder, Chewing	Wound healing; Body swollen, Chest infection in children, Urinary disorder, Male in soft organ swollen. Toothache	54	7	0.290	0.272
65.	*Rumex dentatus* L.	JhagliPalik	Leave, Seeds	Powder, Chewing	Flue, Diarrhea, Obesity	11	3	0.059	0.130
66.	*Salvadora persica* L.	Khabar	Root, Soft bark, Leaves, Fruit	Toothbrush, Powder, Infusion, Decoction	Skin Allergy, Gastric disorder, Mouth cancer, Mouth freshener, Dysuria	64	6	0.344	0.163
67.	*Senna italica* Mill.	Ghorawl	Whole plant, Root, Flower, Leaves, Seed	Chewing, Powder, Decoction	Vomiting, Body swollen, Mouth infection, Joint pain, Moon soon fever, Cough, Stomach ulcer Urinary disorder, Toothache	55	9	0.295	0.095

68.	*Senna occidentalis* (L.) Link	Sana makhi	Seeds, Flower	Powder Oil	Body pain, Diarrhea Obesity, Cardiac disorder	42	4	0.225	0.12
69.	*Solanum surattense* Burm. f.	JhaliWaghan	Root, Fruit, Flower	Decoction, Powder	Enhance urination, Jaundice, Dysentery, Antidandruff	31	4	0.166	0.125
70.	*Sonchus acaulis* Dum.Cours.	Jhazipan	Whole plant, Flower	Powder, Decoction	Asthma, Cough	16	2	0.086	0.068
71.	*Sonchus arvensis* L.	Jhazboti	Whole plant	Powder	Breast swollen, Asthma	29	2	0.155	0.095
72.	*Sonchus oleraceus* (L.) L.	Kapriboti	Leaves, Flower	Decoction, Paste	Rheumatism, Skin eruption	21	2	0.112	0.060
73.	*Tecomella undulata* (Sm.) Seem.	Rahiro	Bark, Flower	Paste, Decoction, Poultice	Wound healing, Urethra ulcer, Enhance Spermatogenesis	31	3	0.166	0.058
74.	*Tephrosia purpurea* (L.) Pers.	Jhalimattari	Root, Seeds, Flower	Juice, Powder, Decoction	Blood in Urine, Jaundice, Leprosy	51	3	0.274	0.084
75.	*Tephrosia uniflora* Pers.	Jhagli phalli matri	Whole Plant, Seed, Leaves	Decoction, Powder	Bronchitis, Pimples and bleeding piles, Cough, Jaundice, Kidney disorder	59	5	0.317	0.088
76.	*Withania somnifera* (L.) Dunal	Kandari	Root, Fruit, Leaves	Decoction, Powder	Cough, Phlegmatic Fever, Asthma, bronchial Headache, Joints pain	38	8	0.204	0.060
77.	*Withania coagulans* (Stocks) Dunal	Asghand	Root, Seeds	Decoction, Powder	Bronchial disorder, Digestive disorder	33	2	0.177	0.061

78.	*Zaleya pentandra* (L.) C.Jeffrey	Acho Wahoo	Whole plant, Leaves, Root	Cooked, Decoction, Powder	Dysentery, Jaundice, Urinary disorder	49	3	0.263	0.105
79.	*Ziziphus jujuba* Mill.	Beri	Fruit, Bark, Root	Juice ,Powder	Purification of blood, Digestion disorder, Diarrhea, wound, Ulcer, Poultice and Fever	61	6	0.3272	0.21

FC*1 = Number of informants who reported the species for the treatment

UR*2 = Total number of uses reported for the species

RFC*3 = Relative frequency of citation, depict the importance of the species in local area

UV *4= Use value, highlight the importance of species based upon the number of uses

3.3.5 Important Ethnomedicinal Phytotherapies used in Human Diseases

Cistanche tubulosa

A decoction (400mL) of the entire plant is used against tetanus and blindness. Locally the drug is administered for treatment of pregnancy complications. Either a concoction of the stem is made, or the dried stem powdered which is then administered to the patients of diabetes. Whole plant used as a decoction and infusion for Impotency, cough, gastric ulcer, vomiting and diarrhea. C. tubulosa have been traditionally used as a promoting agent against dysentery and treatment of sexual disorders.

Crotalaria burhia

200 gram roots is boiled in water, the filtrate has a good wound healing effect and can be taken orally against hydrophobia, the leaves can be applied externally on wounds and cuts, and the root juice with sugar can be given to cure kidney pain. The root of the plant is used for rheumatism. Dried plants material is ground, mixed with water and filtered, and can be used for diarrhea, typhoid and gout. Root decoction of Crotolaria burhi, Mullago cerviana, Zingeber officinal and Trachyspermum ammi is given in nausea. Root extract is given with sugar to cure cancer. Bast fibre extracted from the stem used for ropes and cordage to make huts using dry plants. The branches and leaves decoction are useful in placenta delivery.

Peganum hermala

200-340 grams dried leaves are grinded and along mixed with Anthem sowa seeds. This mixture is filtered with a cloth and is given to patients suffering from abortion. They are also used in jaundice, obesity, and other muscular disorders using 100 mL of drug is given thrice a day for 4 to 10 days. The seeds yield a dye, which is used for dyeing the hair as an identification mark.

Salvadora persica

The infusion of the root (300mL), the root of Tamarix aphylla and the leaves of Aloe species is administered orally against urinary and gastric disorders. The juice of the leaves is given to cure skin allergy. The natives use root as toothbrush as it strengthens the gums, keeps them from becoming spongy, and improves digestion.

Alhahi maurorum

The extract from fresh leaves (125 mL) is used as infusion to relieve chest and joint pain. The powdered roots are taken as anti-diabetes. Decoction of three handfuls of fresh whole plant in 1 L. Drink half glass two times for 4 days for treatment of stomachache. Equal number of leaves and flowers are mixed together and ground it into paste and mixed with coconut milk. The medicated milk is consumed half cup twice a day to remove kidney stones.

Euphorbia hirta

The two leaves along with a betel leaf, a betel nut is cut into small pieces and are to be taken. The hands are to be wetted and the breasts touched with wet hands while thinking of increased lactation due to beneficial effects of its decoction for 3 days. The milk-like juice (250 mL) of the leaf is also taken for increased lactation. Juice squeezed from the leaves is applied to affected areas for asthma, cough and vomiting. The whole plant is boiled in water and the water taken as remedy for gonorrhea and chronic bronchitis.

Moringa olifera

Decoction (300 gram) of a handful of fresh leaves in 1L of water. Drink 2 glasses thrice for 3 days for paralysis. Raw seeds or leaves cooked for 3 to 10 min to treat urinary disorders. Root cut in small pieces with root of Carica papaya, slices of orange, white onion and water. The juice drink 3 glasses/day for 30 days to cure face spots. The ripe leaves are blended to obtain juice. One oleifera cup of the juice is taken every morning and evening as sexual tonic. Flowers are used as vegetables commonly known as "Saag" by local people while leaves are used as fodder by goats. Gums obtained from the trunk used to cure joints diseases.

Senna italica

The infusion (200-300 mL) of the fresh whole plant is drunk, and the marc applied to the swollen areas of body. Dried leaves powdered and boiled with water and drunk after adding goat or camel milk to cure moon soon fever. A tablespoon of powdered roots are infused in 2 L warm water or crushed roots are boiled for 7 15 min. 300 mL full cup is taken twice a day orally to cure urinary complaints and vomiting. Leaf extract boiled for 4 to 8 minutes.is taken orally twice a day for toothache.

Calligonum polygonoides

Flowers used as vegetable, floral buds and green twigs are chewed and paste on skin to remove dandruff. Leaf extract (200 gram) of the plant is taken in cases of typhoid, whereas a decoction of the plant is gargled to cure abdominal pain. Aqueous paste of whole plant is given orally to the person who has taken heavy dose of opium as it acts as medicine. It gives cooling effect to the body. The juice of plant applied in eyes to remove the poisonous effect of *Calotropis procera* latex if gets in to or contacted with eyes. Decoction of the plant after boiling is used as to cure skin dryness.

Heliotropium crispum

Juice from leaf and stem (250 ml) is given once daily against scorpion venom which act as antidote. Paste of leaves along with ginger is applied to fractures of ones. The dried plant along with sugar candy (Misri) is grinded in water and is used cure redness of eyes. One teaspoonful soaked in a cup of hot water. Honey may be added. To be taken twice daily for two months for blood purification.

Heliotropium bacciferum

320 grams whole plant is placed in water overnight and taken half cup of this water daily before breakfast. Prolonged decoction to concentrate the juice; it has to be drunk with sugar against urinary complaints. Plant extract or leaf paste is applied locally on palms, soles or body or mixed with extract of bulb of *Allium cepa* and used 2-3 times a day to treat asthma. Root is dried, grinded and the powder used for treating wounds.

Neurada procumbens

Root paste (130 grams) used as sexual tonic. Leaf extract used against skin disease. Fruit decoction given to children to reduce blockage in veins (about 10-15 ml only). Leaf juice mixed with food given for blood pressure stimulation and urinary disorders. For a dose about 200 grams of bark are crushed finely and juice was obtained taken as dose is continued for a week against dysentery.

Pithecellobium dulce

The pulpy ripened fruits are sweet in taste. These also cure malaria. Treat gastroenteritis, root good remedy for diarrhea and dysentery. Dried powdered leaves (300-380 gram) are used as sexual tonic. Works as lightens skin, prevents hair loss, aids weight loss and

good for pregnant women.

Glinus lotoides

Crushed seeds and mixed with Linum seeds (250 gram) and then eat it against blisters on face. Leafy stem of this herb is powdered, and their juice is prepared by mixing with sweetening agent and the patient drinks it as blood purifier. Root paste is given orally against white discharge and flower paste mixing with aste of Santalum album.

Haloxylon stocksii

300–500-gram whole plant ash and mixed with sugar against menstrual problems. The plant ash is applied externally to cure skin diseases. Spleen enlargement is known to be cured by mixture of plant ash in water. A decoction of this plant is used by local physicians to treat urinary diseases.

3.3.6 Most Commonly Used Plant Species in the Treatment of Human Diseases

The analysis showed that the most reported species were *Accacia Senegal, Avena sativa, Calligonum polygonoides*, *Crotalaria burhia*, *Fagonia cretica*, *Haloxylon stocksii*, *Medicago lupulina*, *Mollugo cerviana*, *Neurada procumbens*, *Parkinsonia aculeata* and *Withania somnifera*. These species indicate the ethnomedicinal importance in rural communities for healthcare.

A. Senegal was reported for throat infection, diarrhea and cough. In literature, it is commonly cited against respiratory infections, stomachic, abdominal pain and toothache (Magnini, 2020; Yebouk et al., 2020) against mumps, eye injury and impotence (Teklehaymanot, 2017). *A. sativa* was reported for treatment of muscular disorders and diarrhea. In few studies, it was reported for stomachic and against skin diseases (Hussain et al., 2018; Zari and Zari, 2015). *C. polygonoides* was reported to cure stomach, urinary and bone disorders, scabies bite, typhoid and asthma. Obolskiy et al., (2009) and Heneidy et al., (2017) reported it against to inducing abortion, antidote for scorpion sting and used as anti-ulcer for stomach complaints. *C. burhia* was specifically reported for kidney infections, wounds and typhoid. In earlier studies,it has reported against skin diseases and diarrhea regarding its ethnomedicinal uses (Swarnkar et al., 2019; Ahmad et al., 2014). *F. cretica* was reported for brain tumor, cancer and reproductive infection in current study whereas Tariq et al., (2015) reported this herb aerial part against skin allergies.

Haloxylon stocksii was reported for urinary disorder, menses problems and spleen enlargement while in earlier studies its decoction was used to treat viral disease and ash of the plant is used to treat internal ulcers (Hussain et al., 2006; Issa et al., 2018). *M. lupulina* was described for treating jaundice and piles, whereas Rathore et al., (2012) mentioned tea from aerial parts was used internally for increasing vaginal secretion. In this study *M. cerviana* was reported for jaundice ulcer, rheumatism. In literature, it is documented against asthma and gonorrhea (Ahmed et al., 2014; Šarić-Kundalić et al., 2010). *Neurada procumbens* was documented for cardiovascular disorders, skin diseases and urinary complaints while Napagoda et al., (2018) cited it against liver infection, insect biting. In another study, *N. procumbens* reported for sexual problems, eczema and removal of bladder stone (Ahmed et al., 2019). *P.*

aculeata was used to for treating gall bladder disease while earlier documentation of Rehman et al., (2015) reported it for diabetes and asthma. *W. somnifera* was documented in this investigation was used to treat cough, phlegmatic fevers and bronchial asthma however Naryan and Singh, (2017) reported that *W. somnifera* root powder is taken orally with cow milk to increase fertility for conception in women. Wubetu et al., in (2018) showed that inhalation of root smoke is used for insomnia treatment. Heinrich et al., (1998) concluded that ethnobotanically important plant species are those that are reported by large number of study participants. Meanwhile, above reported plant species are precious ethno-medicinal species of Southern desert of Sindh.

3.3.7 Quantitative Ethnomedicinal data

In present study, documentation of quantitative ethnomedicinal data, use reports, use value and relative frequency of citation indices were analyzed. The RFC and UV values obtained from the given species indicate how much indigenous knowledge about the use of medicinal plants in the treatment of various diseases is shared by local people. These RFC and UV values were found to be greater in some development recommendations. The most essential plants used to cure various health issues were identified through quantitative analysis of the data utilizing URs, RFC, significant medicinal species, which could be attributable to the increasing use of herbal medications in Sindh's Southern Deserts. The RFC and UV indices are used to identify promising plant species for further pharmacological research and medication and UV.

a) Used Reports (UR)

A use report (UR) is a single person's citation of a single plant species for a single indication. A multi-purpose plant reported by a single source will have various uses (Odonne et al., 2013). In the present study, Use report value varied from 1 to 13. The most commonly used species were Cistanche tubulosa 13 reports by 58 informants, Crotalaria burhia 11 reports by 51 informants, Euphorbia hirta, Senna italica (9 reports each) and Calligonum polygonoides (8 reports). The least used species were Hibiscus scindicus and Ochradenus baccatus (1 URs for each). These species were used for diverse purposes, including sexual tonic, bone fracture, eye infection, dysentery, rheumatism, gonorrhea, diarrhea, respiratory tract infections, cure kidney infection, anti-cancer, gout, leukoderma, placenta delivery, asthma, cough, urinary disorder, scabies bite and eczema

while the three species with lowest URs were solely used to treat eye infection, wound infection and for sexual increase respectively. Each citation of a particular part of a particular species was recorded as one-use report. When a species was mentioned to be used to treat or the manage different ailments in the same category, it was considered as a single use- report (Zatout et al., 2021). It is found that plants having more use reports (UR) always have high UV while plants having fewer UR reported by informants have low UV (Kayani et al., 2015).

b) Used Value (UV)

The use value was used to calculate the relative importance of the plant on the basis of the number of uses of the plant and the number of people it considers useful (Ong et al., 2018). The use value is applied for determination of important species based upon reported uses. In the present study, dulce (0.227) and Salvadora persica (0.163). while lowest was found for

the UV ranged from 0.022 to 0.263. The highest UV was found for Moringa oleifera (0.263), followed by Pithecellobium Heliotropium bacciferum and Indigofera cordifolia (0.022 each). The previous findings of Abe and Ohtani (2013), reported highest used value of M. oleifera was used against circulatory system disorders. From literature, Pithecellobium dulce was commonly used species with indigenous used for the treatment of arthritis (Ong et al., 2014). Salvadora. persica was reported 85% of the respondents because of its significance in dental hygiene and also as a medicine (Halawany, 2012). The earlier studies of Muthee et al., (2011) mentioned the used value of S. persica was used to treat stomachache. Our ethnomedicine data documentation shows that in modern times, plants with higher UVs have been more commonly used for a variety of treatment of diseases. This is an interesting outcome and explain the importance of medicinal plants in the desert region. Plant species used repeatedly are biologically more active and it is not necessary for a low valued plant to become unessential or not biologically active as used value is constant in specific areas, but may vary depending on the difference in indigenous people's knowledge from area to area (Amjad et al., 2020). According to Ahmad et al., (2018), plant species which were not previously studied but have a high UV should be further assessed using pharmacological and phytochemical techniques for drug discovery.

c) Relative frequency of citation (RFC)

The plants species which are commonly utilized for the various diseases and disorders are assess by the relative citation frequency (RCF). Highest RFC value were calculated for *Glinus lotoides* and *Haloxylon stocksii* (0.505 each) followed by *Heliotropium crispum* (0.483 each) and *Heliotropium bacciferum* (0.456). and least RFC were calculated for *Medicago lupulina* (0.064). In literature, *G. lotoides* showed highest RFC value was used against scabies, rheumatism and dyspepsia (Vijayakumar et al., 2015). Mechaala et al., (2021) recently reported highest frequency of citation in *Haloxylon stocksii* against gestion, scorpion bite and skin diseases. In *Heliotropium* species RFC value evaluated against lower back ache, asthma, eczema, kidney stones and urinary infections (Sreekeesoon and Mahomoodally, 2014; Sargin et al., 2015). It means that these species are the most popular medicinal plants agreed by the majority of the informants and they are the most popular plants in Desert region with high RFC values have shown their abundant use and widespread awareness among local communities (Faruque et al., 2018). The reasoning behind their highest RFC values may be that they are used in traditional herbal recipes. This indicates that traditional medicine practitioners are well known for their clinical virtues and their large distribution in the study area. Moreover, these species are native to the area and have long been known to local cultures. Thus, their specific properties for treating different disorders have been popularized and well known among indigenous peoples. The lowest RFC value (0.064) recorded for *Medicago lupulina* have limited availability in the study area. However, as referred to Dudney et al., (2015), the UV parameter is not capable of distinguishing between the number of informants citing the species or the consensus among those uses, so the analysis of the species significance, derived solely from the UV value, is very limited; other parameters, such as the RFC, are therefore recommended.

3.3.8 Summary

This study is confined with documentation of ethnobotanical uses of medicinal plants of Southern Deserts of Sindh-Pakistan. A total of 79 plant species belonging to 48 plant families are reported from 186 study participants using semi-structured, open ended and group interviews. In educational perspective, most of the informants had either illiterate (29%) or 5 years education (23%). The most cited families were Fabaceae (13 species) followed by Amaranthaceae and Cucurbitaceae (6 species each) while most of species belongs to herb life form (36 species). Among reported plant species, *Senna italica, Solanum surrattense, Fagonia bruguieri, Fumaria indica, Mukia medraspatana* and *Opuntia dillenii* had highest importance among informants and considered as precious medicinal plants species that rarely available in different habitats in Pakistan. In life formsIn life forms, most of the reported plant species wereherbs (71%), followed by trees (11%), shrubs (10%) while climbers (7%) and trailers (1%). The leaves (22 %) were the predominantly used plant parts for preparation of herbal recipes, followed by seeds (20 %), flowers (19 %) and whole plant (17 %) while least reported parts used were barks (3%) and other parts including rhizome, latex, gum etc. (3%) The most frequently cited plant part used were leaves (45records) followed by seeds (27 records) while least used part was whole plant. The most dominant mode of utilization was Powder as predominantly reported with 35% reports, followed by decoction (31 %) and juice (14 %). Based on UR data, the five most used ethnomedicinal plant species were *Cistanche tubulosa (*13 reports), *Crotalaria burhia* (11 reports), *Euphorbia hirta, Senna italica* (9 reports each) and *Calligonum polygonoides* (8 reports). The least used species were *Hibiscus scindicus*, *Ochradenus baccatus* and *Pisum sativum* (1 report each). The use value ranged from 0.02 to 0.428. Highest value was reported for *Merremia hederacea* (0.428) followed by *Ricinus communis (*0.290), *Moringa oleifera* (0.263), *Trigonella foenum-graecum* (0.21) and *Pithecellobium dulce* (0.227). The lowest value was accounted for *Heliotropium bacciferum* and *Indigofera cordifolia* (0.022 each). Highest RFC values were calculated for *Glinus lotoides* and *Haloxylon stocksii* (0.5 each) followed by*Enicostemma hyssopifolium* and *Heliotropium crispum* (0.483 each) and *Heliotropium bacciferum* (0.456).

3.3.9 Pictorial overview of medicinal Plant used in Treatment of Human Disorders

Plate 41: A) *Acacia Senegal* B) *Albizia lebbeck*

Plate 42: A) *Alhagi maurorum* B) *Anticharis glandulosa*

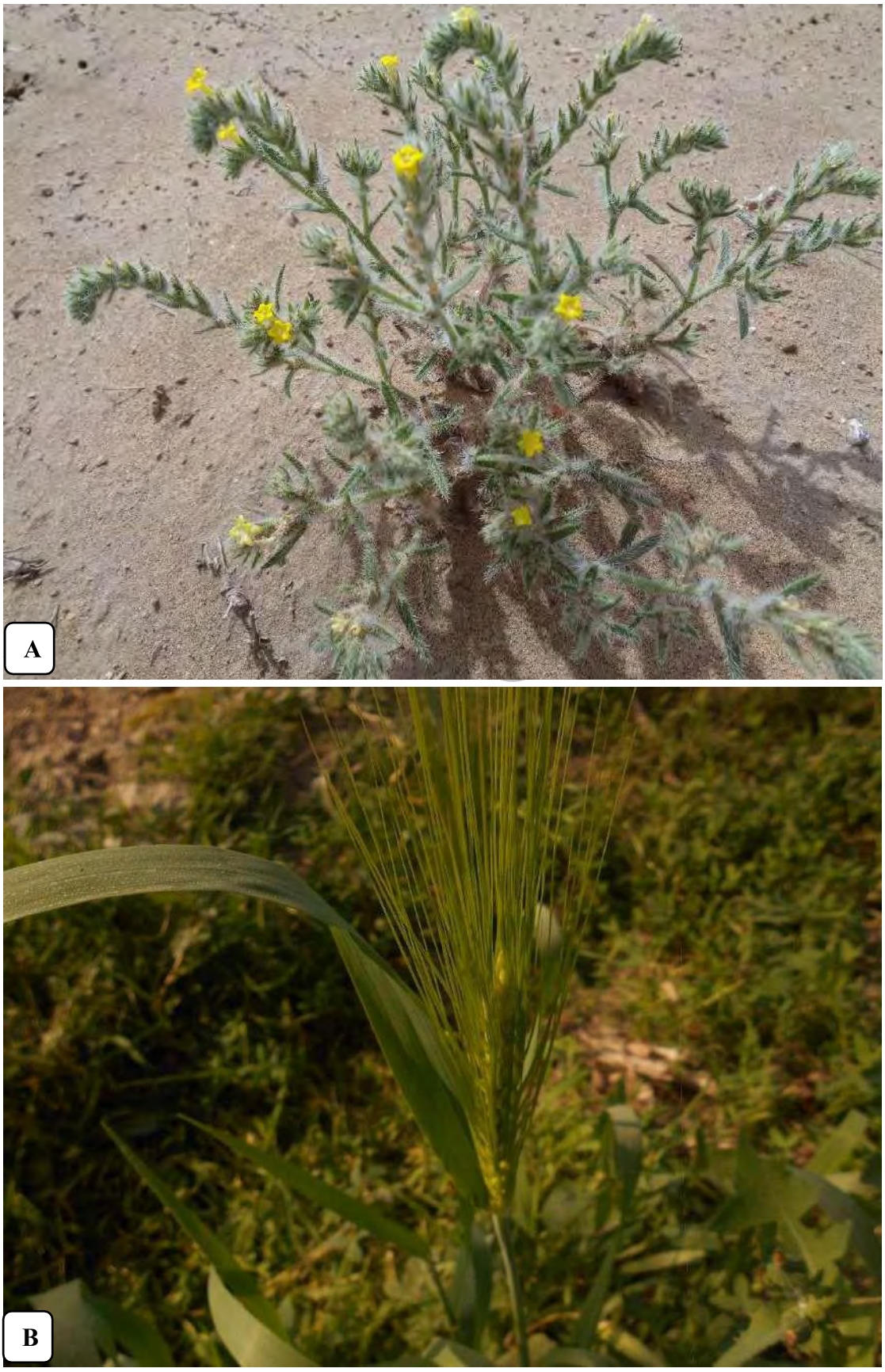


Plate 43: A) *Arnebia decumbens* B) *Avena sativa*

Plate 44: A) *Azadirachta indica* B) *Calligonum polygonoides*

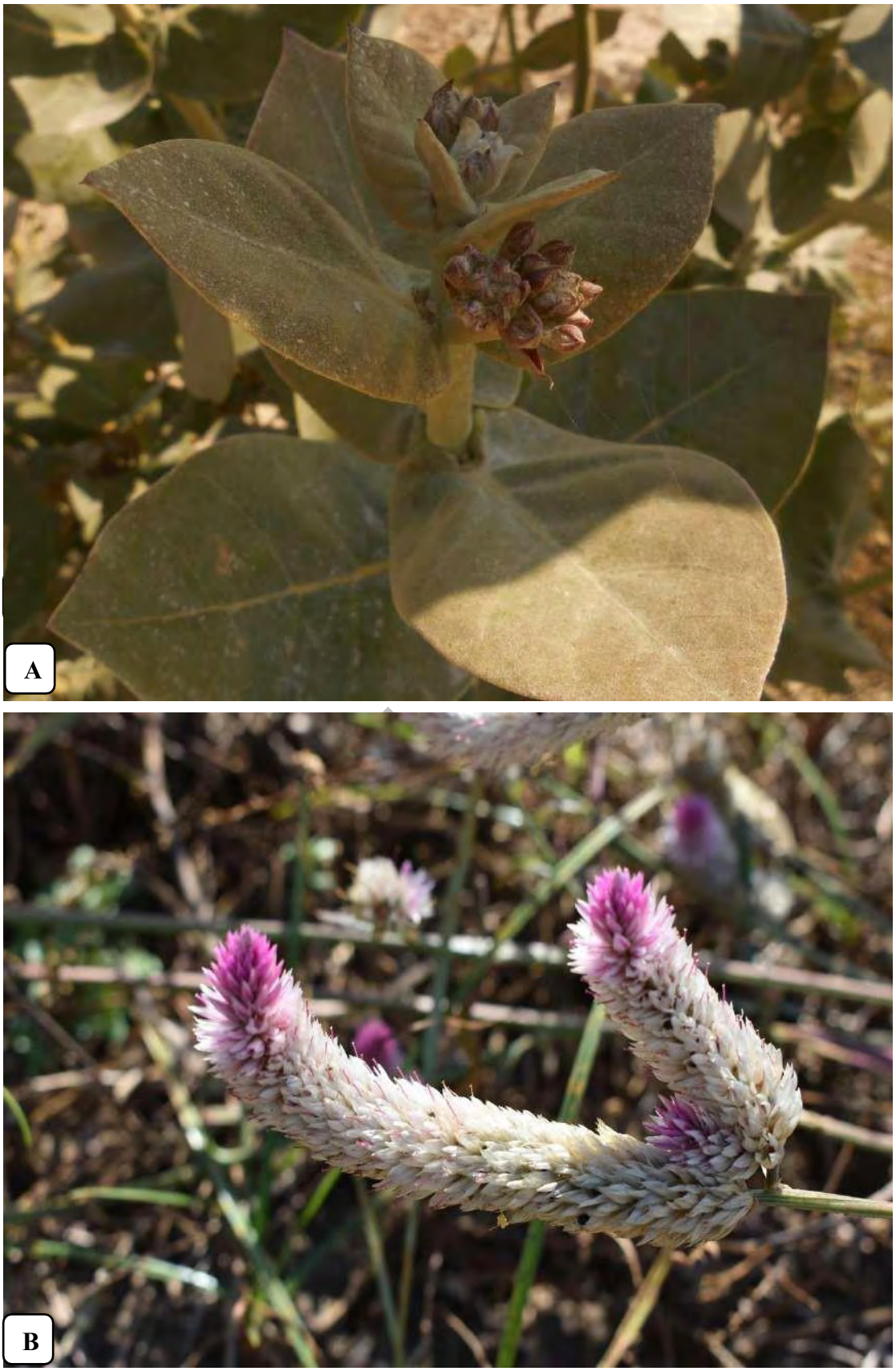


Plate 45: A) *Calotropis gigantea* B) *Celosia argentea*

Plate 46: A) *Cenchrus biflorus* B) *Chenopodium album*

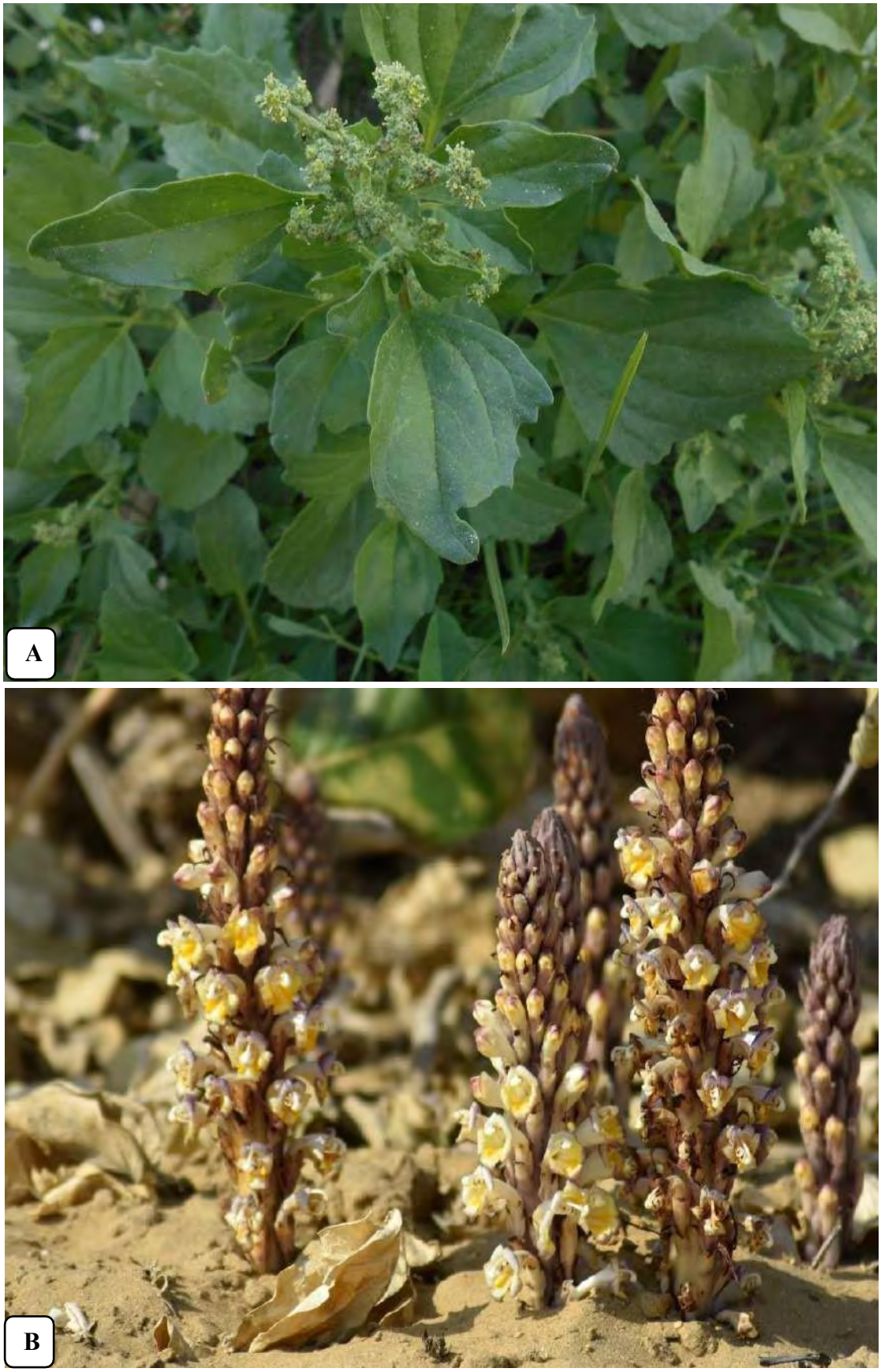


Plate 47: A) *Chenopodium murale* B) *Cistanche tubulosa*

Plate 48: A) *Citrullus lanatus* B) *Cocculus hirsutus*

Plate 49: A) *Convolvulus prostratus* B) *Crotalaria burhia*

Plate 50: A) *Crotalaria medicaginea* B) *Cuscuta reflexa*

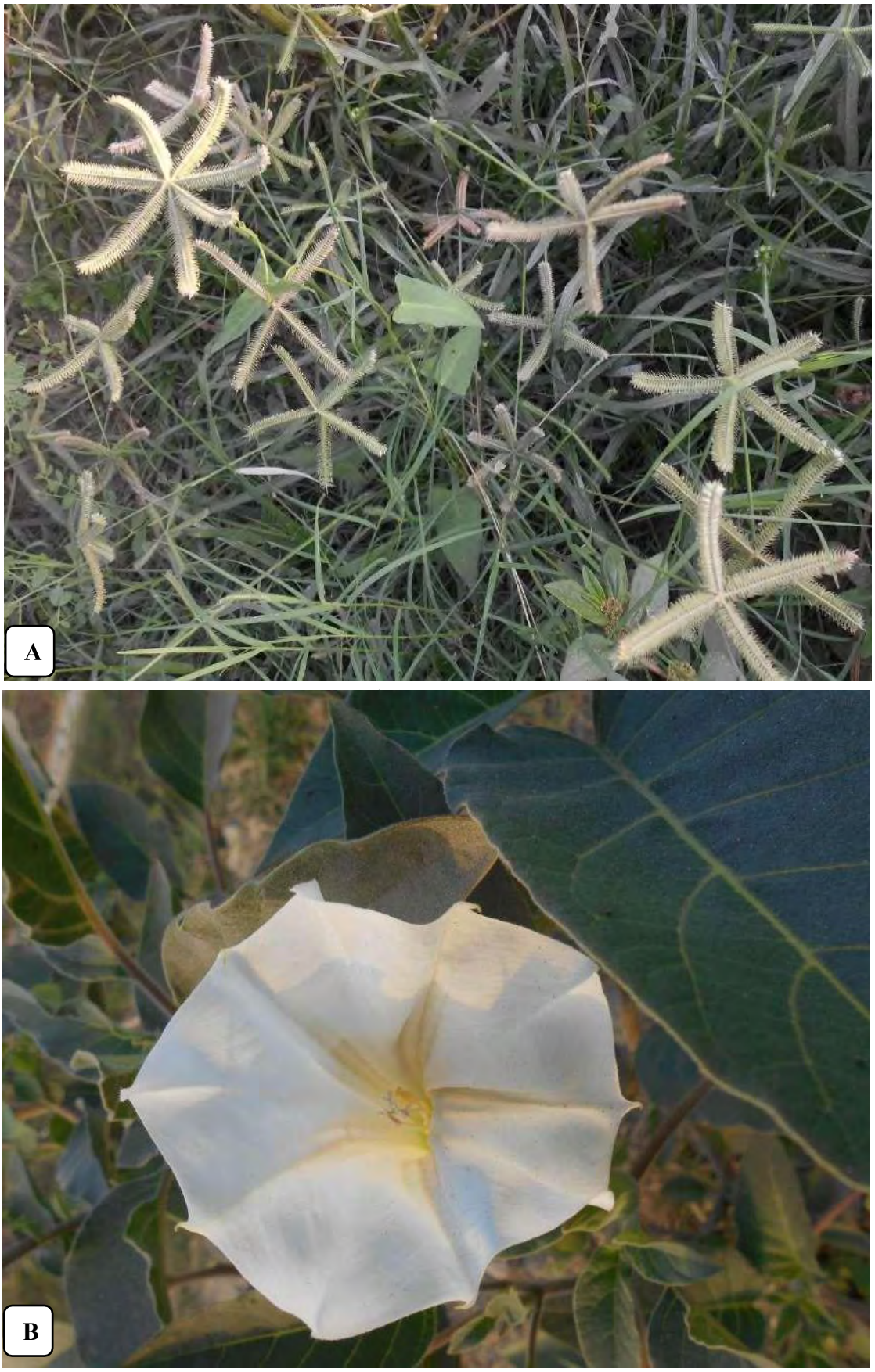


Plate 51: A) *Dactyloctenium aegyptium* B) *Datura innoxia*

Plate 52: A) *Enicostemma hyssopifolium* B) *Eucalyptus globulus*

Plate 53: A) *Euphorbia granulata* B) *Euphorbia hirta*

Plate 54: A) *Fagonia cretica* B) *Glinus lotoides*

Plate 55:A) *Gnaphalium polycaulon* B) *Grangea maderaspatana*

Plate 56: A) *Haloxylon stocksii* B) *Heliotropium bacciferum*

Plate 57: A) *Heliotropium europaeum* B) *Heliotropium crispum*

Plate 58: A) *Heliotropium strigosum* B) *Hibiscus scindicus*

Plate 59: A) *Indigofera cordifolia* B) *Iphiona grantioides*

Plate 60: A) *Ipomoea cairica* B) *Launaea procumbens*

Plate 61: A) *Lawsonia inermis* B) *Lepidium sativum*

Plate 62: A) *Medicago lupulina* B) *Melilotus albus*

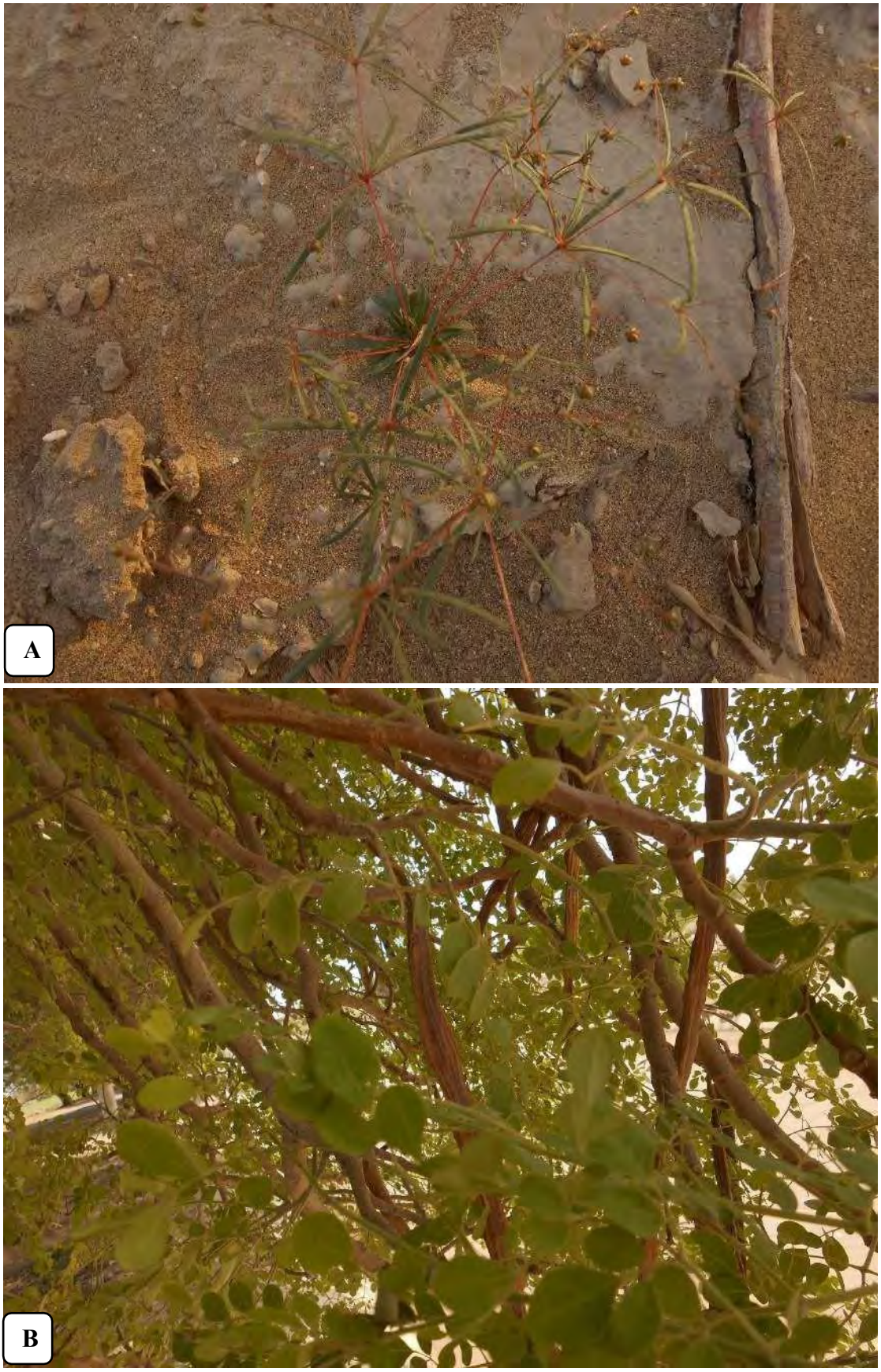


Plate 63: A) *Mollugo cerviana* B) *Moringa oleifera*

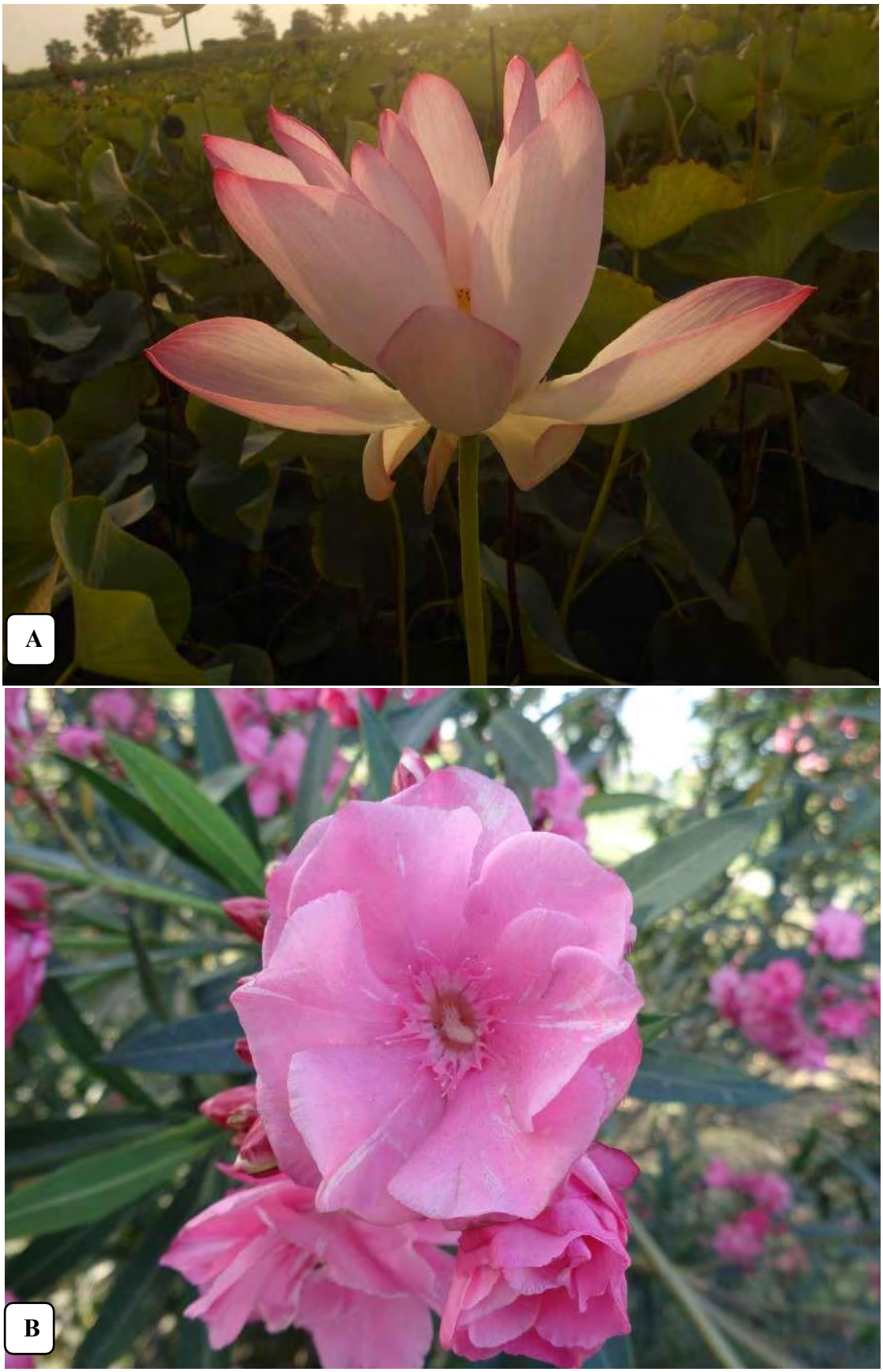


Plate 64: A) *Nelumbo nucifera* B) *Nerium oleander*

Plate 65: A) *Neurada procumbens* B) *Nicotiana tabacum*

Plate 66: A) *Ochradenus baccatus* B) *Ocimum basilicum*

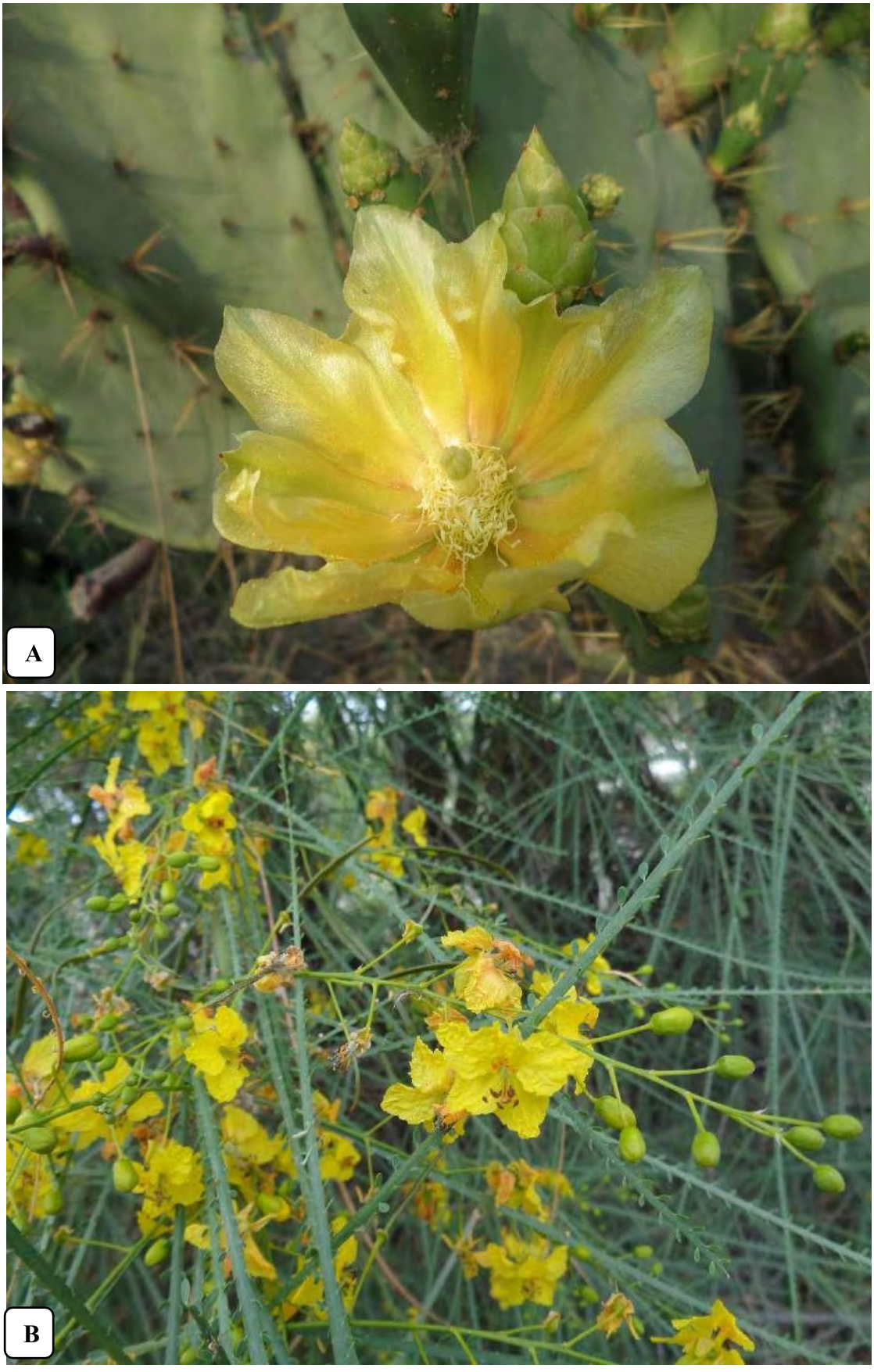


Plate 67: A) *Opuntia dillenii* B) *Parkinsonia aculeata*

Plate 68: A) *Peganum harmala* B) *Physalis peruviana*

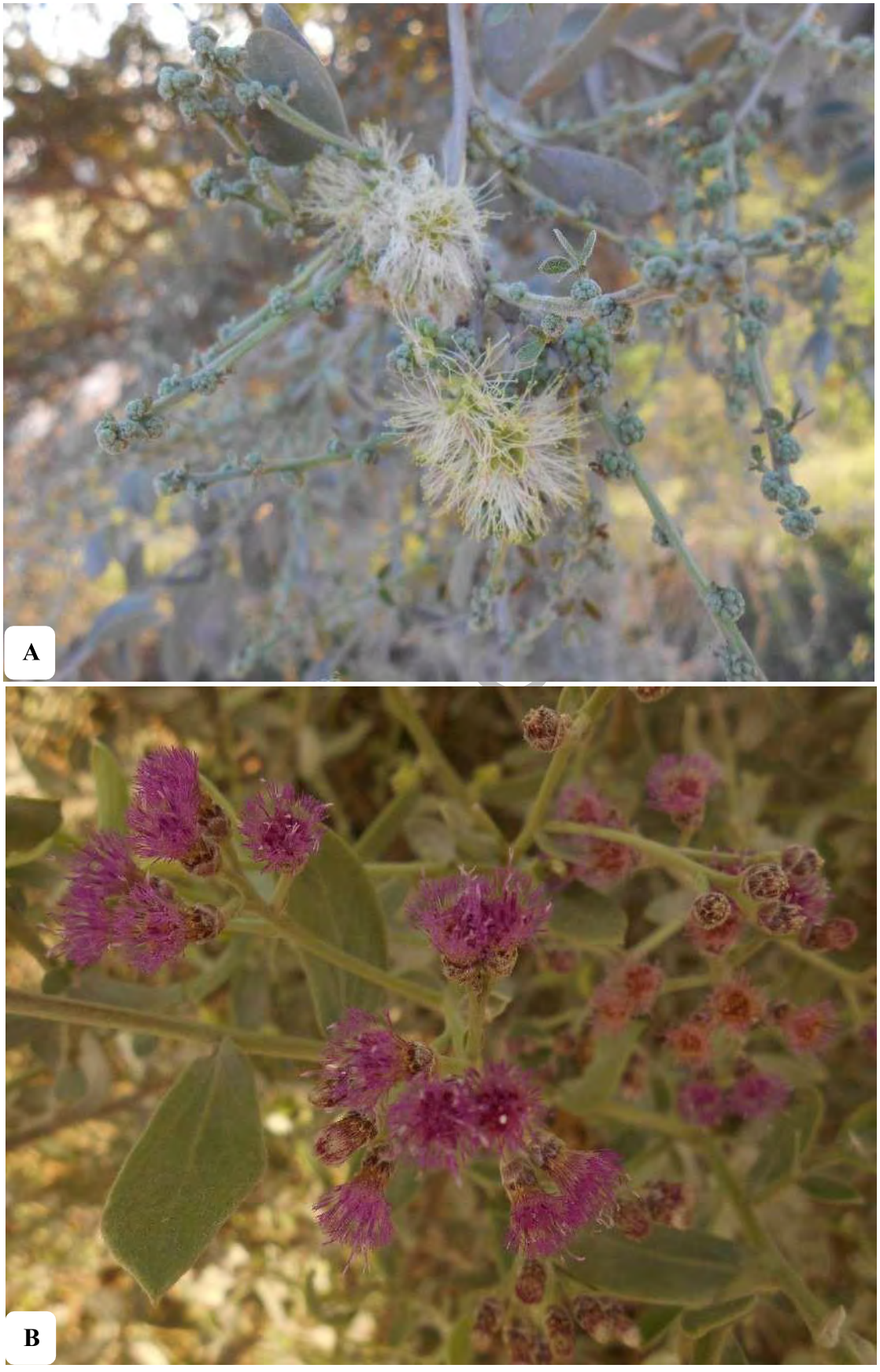


Plate 69: A) *Pithecellobium dulce* B) *Pluchea arguta*

Plate 70: A) *Pulicaria undulata* B) *Rhazya stricta*

Plate 71: A) *Ricinus communis* B) *Rumex dentatus*

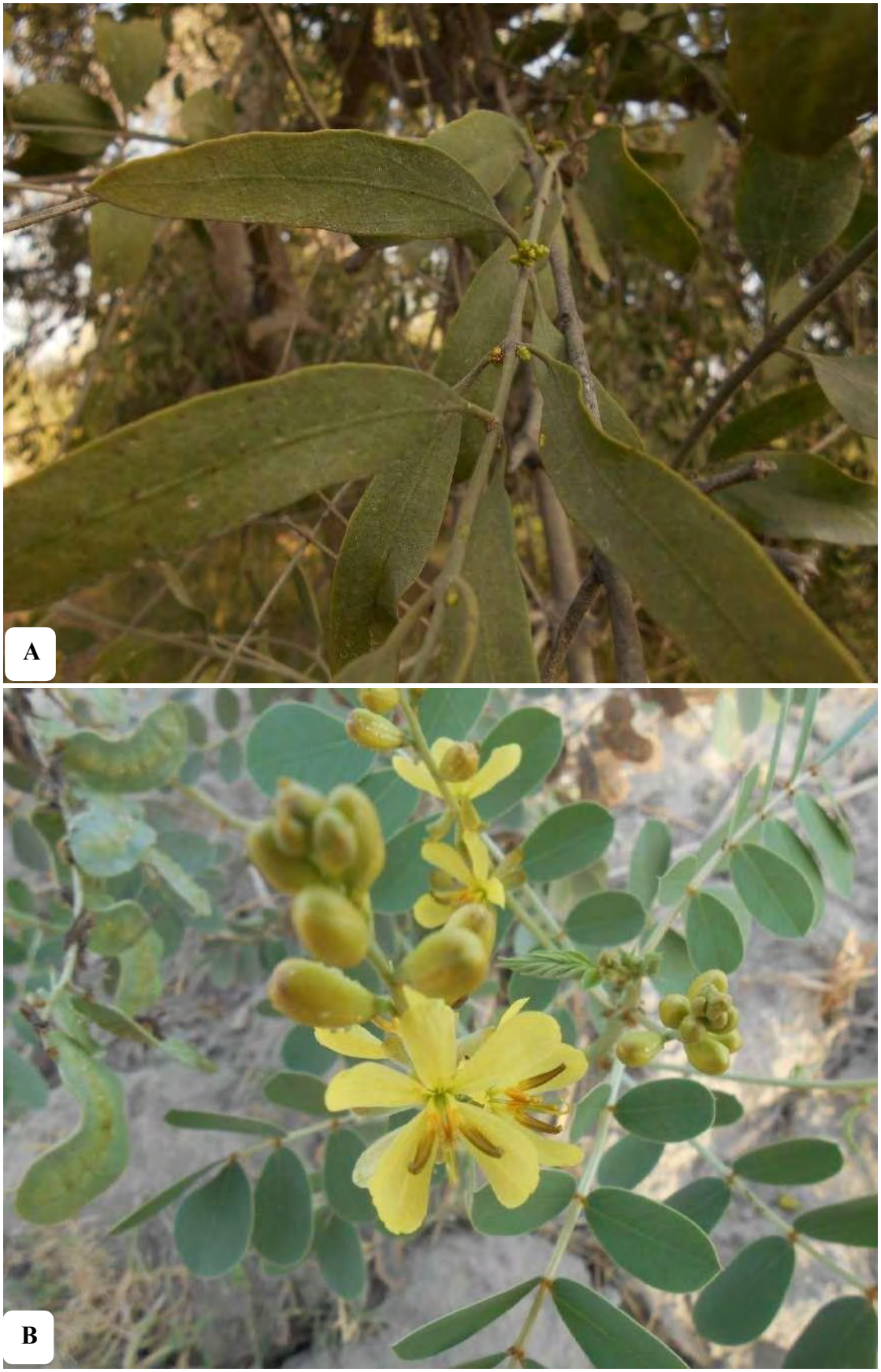


Plate 72: A) *Salvadora persica* B) *Senna italica*

Plate 73: A) *Senna occidentalis* B) *Sonchus acaulis*

Plate 74: A) *Sonchus arvensis* B) *Sonchus oleraceus*

Plate 75: A) *Tecomella undulata* B) *Tephrosia purpurea*

Plate 76: A) *Tephrosia uniflora* B) *Withania somnifera*

Plate 77: A) *Withania coagulans* B) *Zaleya pentandra*

Section IV

Pollen Morphology of Medicinal plant species used in Treatment of Livestock and Human Diseases

3.4.1 Morpho-palynological findings

The main morphological and micro-morphological features of the investigated pollen grains of medicinal plants are summarized in Tables 9 and 10, while SEM photomicrographs of are shown in Plate 78 to 84.

3.4.2 General Pollen Descriptions

The classification of pollen size according to Erdtman (1952), the examined pollen is small (1-24 mm; 35.71%), medium (25–50 mm; 53.28%), and large (50–100 mm; 7.69%). The shapes of grains are prolate spheroidal, spheroidal, prolate, sub-prolate, oblate and sub-oblate in equatorial dimensional view. Most species have tricolporate pollen and only a few have trizonocolporate, monoporate, tetracolporate, monosulcate, polyads, hexacolpate and pantoporate pollen grains. The length and width of the colpi and pores and the surface of the aperture membrane are different among medicinal plant species.

3.4.3 Pollen shape and P/E ratio

The pollen morphology of highly medicinal species of deserts showed dominant shapes prolate-spheroidal in 11 species (*Cleome brachycarpa, Cyamopsis tetragonoloba, Enicostema hyssopifolium, Himalaiella heteromalla*, *Melilotus albus, Merremia hederacea, Phalaris minor, Pithecellobium dulce, Polygonum plebeium, Tamarix aphylla* and *Trifolium alexandrinum*), oblate-spheroidal in 4 species (*Corchorus depressus, Heliotropium bacciferum, Prosopis juliflora* and *Spergularia* marina) and spheroidal in *Azadirachta indica, Cucumis sativus* and *Sonchus arvensis*, 3 species (*Citrullus colocynthis, Echinochloa crus-galli* and *Nelumbo nucifera*) have sub-prolate, while in *Coriandrum sativum, Cyperus rotundus* and *Foeniculum vulgare* prolate shape was observed. In *Peganum harmala* and *Prosopis cineraria* sub-oblate type whereas in *Ocimum basilicum* oblate pollen shape was examined. The maximum polar diameter was observed in *Himalaiella heteromalla*
55.85 µm whereas minimum in *Corchorus depressus* 18.1 µm and equatorial diameter was maximum measured in *Peganum hermala* 60 µm and minimum in *Corchorus*

depressus 18.6 µm as shown in (Figure 9). P/E ratio index for each melliferous species was calculated by the ratio of diameter of polar axis to equatorial distance for the determination of pollen shape, ranging from maximum in *Foeniculum vulgare* 1.63 to minimum in *Ocimum basilicum* 0.71 (Figure 10).

3.4.4 Pollen apertures and echini features

In 28 described medicinal species, apertures in the form of colpi and pore were present uniformly on the surface of pollen. Globular, endoporate, exoaperturate and sunken apertures orientation have been reported in studied taxa. Number of apertures observed different in medicinal species ranging from tricolporate pollen type observed in (*Cleome brachycarpa, Citrullus colocynthis, Coriandrum sativum, Enicostema hyssopifolium, Foeniculum vulgare, Himalaiella heteromalla, Melilotus albus, Peganum harmala, Polygonum plebeium*, *Prosopis cineraria, Prosopis juliflora* and *Solanum americanum*), trizonocolporate type pollen in (*Azadirachta indica* and *Sonchus arvensis*), tricolpate type in (*Nelumbo nucifera, Spergularia marina, Tamarix aphylla* and *Trifolium alexandrinum)*, while hexacolpate pollen were observed in *Merremia hederacea* and *Ocimum basilicum*, triporate type examined in *Cucumis sativus* and *Cyamopsis tetragonoloba*, monoporate pollen were examined in *Cyperus rotundus, Echinochloa crus-galli* and *Phalaris minor* and Heterocolporate in *Heliotropium bacciferum*. Pollen aperture showing maximum length in *Prosopis juliflora* 10.6 µm whereas minimum length in *Merremia hederacea* 0.6 µm. The observed aperture width of pollen ranges from maximum in *Spergularia marina* 11 µm to shortest in *Citrullus colocynthis* 1.15 µm as shown in Figure 12.

Echinate pollen examined only on the surface of Asteraceous species significantly an important taxonomic feature. The observed echini arrangement in present findings was rather regular in *Himalaiella heteromalla* while irregular in *Sonchus arvensis*. Echini length observed in *H. heteromalla* was 1.85(1.3-2.55) ±0.14 µm and width was 1.19(0.7-1.67) ± 0.19 µm. In *S. arvensis* the examined length and width of echini was 2.85(1.3-3.75) ±1.4 µm and 1.15(0.85-1.7) ± 0.32 µm respectively.

3.4.5 Sculpturing and Exine thickness

The observed exine ornamentation as a pollen micro-morphological character was greatly varied among medicinal species. Exine ornamentation can be visualizedof diverse types in mdicinal plants: finely reticulate, regulate-reticulate, psilate tectate, scabrate-gemmate, rugulate, scabrate-verrucate, scabrate foveolate, granulose reticulate, scabrate, striate perforate, micro-echinate perforate, psilate verrucate, reticulate, micro granulate, rugulate, reticulate psilate, scabrate, rugulate perforate, sub-psilate, scabrate punctate, scabrate foveolate, psilate, scabrate, echinate, reticulate perforate and papillate striate. Exine thickness as quantitative character analyzed statistically was noted to be maximum in *Enicostema hyssopifolium* 6.3 µm whereas minimum in *Sonchus arvensis* 1.28 µm as shown in (Figure 13).

3.4.6 Discussion

The current research findings on *Azadirachta indica* described the medium sized spheroidal, trizonocolporate, and finely reticulate pollen grains while the earlier study of Maw et al., (2020) found dissimilarity that *A. indica* had tetracolporate pollen with psilate sculpturing of exine. In other study by (Begum and Mandal 2016) stated that pollen shape of *A. indica* was sub-prolate and exine sculpture reticulate was described was found dissimilar to our investigation. The earlier findings of Shabana et al., (2019) stated that in *Citrullus colocynthis* pollen of circular elliptic shaped with coarsely reticulate ornamentation having large exine thickness was observed whereas outcomes of our research elaborate polyhedral and psilate tectate grains.

The *C. viscosa* grains were tricolporate with prolate-spheroidal shape and reticulated surface were different from earlier study of Mir et al., (2019) revealed that pollen of *C. viscosa* were characterized by prolate shape and regulate reticulate ornamentation. In *Coriandrum sativum* prolate, ovate pollen with scabrate gemmate sculpture was examined in present study whereas Öztürk et al., (2018) stated earlier that *C. sativum* pollen grains are tricolporate, prism shaped, triangular with a finely reticulate sculpturing was observed. While according to Alam et al., (2020) pollen of *C. sativum* was prolate spheroidal, ovate and spines present was observed which was

found contradicted with our findings. According to Shinwari et al., (2015), *C. sativus* scabrate grains with annulate and triporate features were observed. While the obscure exine attributes according to Quamer et al., (2017) and sub-spheroidal grains with noted exine 1 µm thick. Whereas Sufyan et al., (2018) was examined scabrate to psilate surface sculpture in *C. sativa* are not in agreement with our current findings.

In the case of *Cypreus rotundus* the previous findings of (Ghosh and karmaker, 2017) shows that spheroidal, monoporate pollen with coarsely micro- reticulate ornamentation was examined. Whereas our research results are not in agreement with the previous work in the case of *C. rotundus* sculpturing granulose reticulate deviate from previous work. In *E. crus-galli* the pollen grains are medium tolarge in size, psilate, monad, prolate, circular, exine sculpturing is fine gemmate and radially symmetrical in polar view. This result is similar to the previous work done byAhlawat, Dahiya, and Chaudhary (2014) and Morim and Lughadha (2015) But this result is dissimilar to the previous work done by El-Amier (2015).

The earlier findings of Seema et al. (2019), who observed bi-colporate, per-prolate, and striate types of grains in *F. vulgare,* were not in accordance with our study. While granulate to rugulate exine with smooth furrows was examined byPuleku et al. (2018), this study elaborates on the verructae scabrate type of exine in *F. vulagre.* In *Foeniculum vulgare* the findings of (Papuleku et al., 2018) shows the prolate triaperturate shape pollen having granulate to regulate sculpture. While in current study scabrate grains with were examined. The pollen grains of *H. bacciferum* were described by Perveen and Qaiser (1995) as prolate, 8-heterocolpate. Gazer, Bous, and Mona (2017) reported the pollens of this specie as prolate, isopolar, pseudoucolpate, and rugulate.

Kamel (2019) presented the similar results to that of Gazer et al. (2017) such as prolate to spheroidal, tetracolporate with alternate pseudocolporate, perforate rugulate. We found mostly similar results to those character described by Kamel (2019) with variation only in ornamentation, described here as verrucate. The researchfindings of Qureshi et al., (2019) illustrate that *Himalaiella heteromalla* grains were

echinate and prolate spheroidal disagreed with our description showing micro-echinate perforate sculpture in *H. heteromalla.*

The results of our study demonstrate the prolate-spheroidal pollen having reticulate peculiarities of exine in *Melilotus albus* while the findings of Bano et al., (2018) explained pollen having reticulate ornamentation. In study by (Lashin, 2007) tectate perforate reticulate exine sculpture features were observed was different from our research. The *Nelumbo nucifera* grains were Sub prolate, tricolpate and regulate surface were different from earlier study of Shubharani et al., (2013) revealed that pollen of *N. nucifera* were characterized by sub-globose and radial symmetry grains. In *Ocimum basilicum* reticulate psilate exine peculiarities and hexacolpate grains were examined that were dissimilar with the earlier studies of Doaigey et al., (2018). While Azzazy (2016) elaborate *O. basilicum* has oblate, colpate and bi-reticulate pollen grains.

The study of Lu et al., (2018) on pollen morphological description of *Peganum hermala* described spheroidal, reticulate ornamented pollen which differs from present findings which elucidate sub-oblate and regulate perforate grains. Our demonstration stated that the pollen of *Prosopis cineraria* is sub-oblate, triangularwith scabrate foveolate sculpture which was found different from the previous studies of Khan et al., (2020) in which psilate to scabrate s ornamentation were examined. Ahmad et al. (2019) gives a general idea of the LM pollen morphological parameters in *P. juliflora* (monad sub-oblate and tricolporate) similar to our findings, whereas Khan et al. (2020) described SEM high resolution structural details elaborates granular colpus and foveolate grains in *P. juliflora.*

Salamah et al., (2019) observed echinate and spheriodal grains in *Sonchus arvensis* while analysis of our results explain pollen grains with trizonocolporate, echinate and lobate in *S. arvensis.* Morphology of pollen in *Tamarix aphylla* reported by Elkordy and Faried, (2017) reported exine sculpture type reticulate and prolate type pollen. Previous woks have suggested that the pollen morphology of *Tamarix aphylla* type by Qaiser and Parveen (2004) described coarse to fine reticulate grains while our results showed that the pollen of *T. aphylla* examined reticulate perforate

type sculptural surface. Khan et al. (2020) studied *Trifolium alexandrinum* pollen grain as elliptic in polar view and per-prolate in equatorial view having reticulate sculpturing which are in disagreement with our findings.

Table 9: Qualitative pollen features of medicinal species

Sr. No.	Taxa	Size	Polar view/ Amb	Shape	Pollen type	Exine Ornamentation
1.	*Azadirachta indica* A.Juss.	Medium	Circular	Spheroidal	3-zoonocolporate	Finely Reticulate
2.	*Cleome brachycarpa (*Forssk.) Vahl ex DC.	Small to medium	Semi Circular	Prolate spheroidal	Tricolporate	Regulate-reticulate
3.	*Citrullus colocynthis* (L.) Schrad.	Medium to large	Polyhedral	Sub-prolate	Tricolporate	Psilate Tectate
4.	*Coriandrum sativum* L.	Small to medium	Ovate	Prolate	Tricolporate	Scabrate-gemmate
5.	*Corchorus depressus* (L.) Stocks	Small	Elliptic	Oblate-spheroidal	Tricolporate	Rugulate
6.	*Cucumis sativus* L.	Large	Circular	Spheroidal	Triporate	Scabrate-verrucate
7.	*Cyamopsis tetragonoloba* (L.) Taub	Small	Slightly Circular	Prolate spheroidal	Triporate	Scabrate foveolate
8.	*Cyperus rotundus* L.	Medium	Slightly circular	Prolate	Monoporate	Granulose reticulate
9.	*Echinochloa crus-galli* (L.) P.Beauv.	Small to medium	Semi Circular	Sub-prolate	Monoporate	Scabrate
10	*Enicostema hyssopifolium* (Willd.) Verd.	Small to medium	Circular	Prolate spheroidal	Tricolporate	Striate perforate
11	*Foeniculum vulgare* Mill.	Small	Circular	Prolate	Tricolporate	Scabrate
12	*Himalaiella heteromalla* (D.Don) Raab-Straube	Medium	Circular	Prolate spheroidal	Tricolporate	Micro-echinate perforate
13	*Heliotropium bacciferum* Forssk.	Medium	Slightly Circular	Oblate-spheroidal	Heterocolporate	Psilate verrucate
14	*Melilotus albus* Medik.	Small to medium	Triangular	Prolate-Spheroidal	Tricolporate	Reticulate
15	*Merremia hederacea*	Medium	Circular	Prolate	Penta-hexacolpate	Micro granulate

	(Burm. f.) Hallier f.			spheroidal		
16	*Nelumbo nucifera* Gaertn.	Large	Circular	Sub-prolate	Tricolpate	Rugulate
17	*Ocimum basilicum* L.	Large	Circular	Oblate	Hexacolpate	Reticulate psilate
18	*Phalaris minor* Retz.	Medium	Circular	Prolate-Spheroidal	Monoporate	Scabrate
19	*Peganum harmala* L.	Small	Circular	Sub-oblate	Tricolporate	Rugulate perforate
20	*Pithecellobium dulce* (Roxb.) Benth	Medium	Semi Circular	Prolate-Spheroidal	Polyads	Sub-psilate
21	*Polygonum plebeium* R. Brown, Prodr.	Small to medium	Rectangular	Prolate-Spheroidal	Tricolporate	Scabrate punctate
22	*Prosopis cineraria* (L.) Druce	Small to larger	Triangular	Sub-oblate	Tricolporate	Scabrate Foveolate
23	*Prosopis juliflora* (Sw.) DC.	Small to medium	Triangular	Oblate-spheroidal	Tricolporate	Psilate
24	*Solanum americanum* Mill.	Small to medium	Lobate	Sub-prolate	Tricolporate	Scabrate
25	*Sonchus arvensis* L.	Medium	Lobate	Spheroidal	Trizonocolporate	Echinate
26	*Spergularia marina* (L.) Griseb.	Medium	Sub Circular	Oblate-spheroidal	Tricolpate	Micro-echinate perforate
27	*Tamarix aphylla* (L.) H.Karst.	Small	Circular	Prolate-Spheriodal	Tricolpate	Reticulate perforate
28	*Trifolium alexandrinum* L.	Small to medium	Slightly Circular	Prolate-Spheriodal	Tricolpate	Papillate striate

Table 10. Quantitative measures pollen parameters of medicinal plants

Plant Taxa	Polar diameter (µm) Max-Min = M±SE	Equatorial diameter (µm) Max-Min = M±SE	P/E ratio	Colpi/pore length (µm) Max-Min = M±SE	Colpi/pore width (µm) Max-Min = M±SE	Exine thickness (µm) Max-Min = M±SE
Azadirachta indica A.Juss.	32.5-64.8 = 49.24±2.54	35.25-59.4 = 49±1.96	1.00	1.05-1.9 = 1.4±0.02	0.95-2.3 = 1.51±0.03	0.8-2.1 = 1.4±0.36
*Cleome brachycarpa (*Forssk.) Vahl ex DC.	22.2-32.7 = 27.4 ±2.08	20.7-31.2 = 25.7 ±2.10	1.06	3.5-5.25 = 4.4±0.33	7.00-8.00 = 7.6±0.20	2.25-6.25 = 3.85±.65
Citrullus colocynthis (L.) Schrad.	33.3–51 = 41.65±1.06	29.5–43 = 34.9±1.57	1.19	0.85-1.7 = 1.2±0.02	0.9-1.5 = 1.15±0.01	1.2–3.6 = 2.25±0.13
Coriandrum sativum L.	37.85-56 = 48.25±1.37	31-45.5 = 35±0.89	1.37	1.85-4.5 = 3.05±0.5	0.7-2.8 = 1.82±0.46	1.5-4.55 = 3.10±0.53
Corchorus depressus(L.) Stocks	16.2-20.5 = 18.1±0.80	17.2-20.2= 18.6±0.64	0.97	1.75-3 = 2.35±0.23	2.75-4.75 = 3.52±0.4	1.75- 4.75 = 3.3±0.59
Cucumis sativus L.	25.6-46.2 = 35.5±1.26	29.5-44.5 = 35.2±1.02	1.00	1.1-2.4 = 1.77±0.08	0.85-2.15 = 1.4±0.06	0.9-2.4 = 1.67±0.52
Cyamopsis tetragonoloba (L.) Taub	20-23.7 = 21.2 ±1.35	17.5-25 = 20.4 ±2.29	1.03	0.5-1.5-= 1.12±0.20	0.5-8.7 = 2.22±3.62	1.75-7.7 = 3.75±1.55
Cyperus rotundus L.	28.4-45.65 = 36.5±1.05	17.5-31.75 = 25±1.12	1.46	0.7-2.1 = 1.45±.02	0.9-1.75 = 1.33±0.01	1.9-3.2 = 2.51±0.4
Echinochloa crus-galli (L.) P.Beauv.	25.50-33.25 = 29.4±0.6	21.50-28.50 = 26±0.88	1.17	A	A	2.10-5.20 = 3.8±0.2
Enicostema hyssopifolium (Willd.) Verd.	23.2-31.2 = 27.4±1.28	20.2-28 = 24.6±1.39	1.11	2.45-4.9 = 3.4±0.34	3.3-6.45 = 4.35±0.56	5.55-7.85 = 6.3±0.34
Foeniculum vulgare Mill.	34.6-44.5 = 39.2±1.03	16.6-33.9 = 24±1.16	1.63	3.1-6.8 = 4.95±0.48	2.7-4.25 3.35±0.79	1.4-2.85 = 2.05±0.04
Himalaiella heteromalla (D.Don) Raab-Straube	46-63.45 = 55.85±1.23	39.5-61.3 = 51.3±2.01	1.11	4.2-7 = 5.85±0.26	2.5-3.9 = 3.15± 0.08	1.7-3.6 = 2.5± 0.22
Heliotropium bacciferum Forssk.	32-41.7 = 37.5±4.32	30.2-45.0 = 39.5±5.73	0.94	4.1-5.5 = 4.85±0.44	7.20-8.50 = 7.9±0.41	2.35-4.75 = 3.6±0.79
Melilotus albus Medik.	37-58.6 = 48.7±1.67	32.5-65.8 = 47.3±1.56	1.03	2.2-6.7 = 4.55±0.58	1.6-4.4 = 2.92±0.5	2.5-6.5 = 4.65± 0.3
Merremia hederacea (Burm. f.) Hallier f.	30.4-42.7 = 36.8±2.08	26.7-41.5 = 35.2±2.1	1.04	0.35-1.65 = 0.6±0.1	0.7-1.7 = 1.25±0.18	2-2.65 = 2.3±0.18
Nelumbo nucifera Gaertn.	38.25-52.4 = 45.2±0.91	27.5-49.0 = 37.4±1.59	1.2	0.95-2.8 = 1.8±0.09	1.4-2.20 = 1.72±0.02	1-1.85 = 1.41±0.01
Ocimum basilicum L.	31.2–53.5 = 42.1±1.62	34.5–84.5 = 59±1.93	0.71	1.35–4.4 = 2.9±0.27	1.2–3.35 = 2.4± 0.42	1.1–2.5 = 1.85±0.02

Phalaris minor Retz.	32-51 = 44.1±7.2	35-48 = 43.5±7.35	1.01	A	A	2.45-5.5 = 3.8±1.4
Peganum harmala L.	42–63.5 = 52.7±1.56	48.2-75.7 = 60±1.29	0.87	4.1–6.4 = 5.24±0.19	3–4.9 = 3.92± 0.21	2.15–3.6 = 2.86±0.04
Pithecellobium dulce (Roxb.) Benth	34.5-35 = 34.9±0.08	30.2-32.7 = 31.6±1.13	1.10	8.5-7.6 = 7.15±1.08	9.5-10.7 = 10±1.01	1.75-3 = 2.55±0.38
Polygonum plebeium R. Brown, Prodr.	20.2-32.5 = 26.5±2.22	17.7-27.7 = 25.1±1.65	1.05	5.15-8.1 = 7.1±0.54	8-10.3 = 9.15±0.31	1.35-5.45= 3.15±0.54
Prosopis cineraria (L.) Druce	29.5-54.5 = 41.9±1.23	42.6-59.5 = 51±1.37	0.82	1.7-3.3 = 2.45±0.12	2.2-5.4 = 3.98±0.38	1.3-2.2 = 1.72±0.04
Prosopis juliflora (Sw.) DC.	23.7-33.= 28.5±1.64	25.0-33.2 = 28.9±1.46	0.98	8-12.7 = 10.1±0.56	3.60-6.8 = 4.8 ±0.46	1.20-2.4 = 1.68±0.21
Solanum americanum Mill.	24-48.2 = 32.5 ±3.6	20.2-35. = 26.9±2.82	1.2	4.25-6.5 = 5.5±0.45	3.50-4.7 = 4.25±0.32	3.20-4.9 = 4.15±0.35
Sonchus arvensis L.	26.7-42.5 = 34.1±0.83	28-39.5 = 33.9±1.14	1.00	1.45-4.2 = 2.7±2.08	0.9.3.6 = 2.14±0.61	0.75-1.9 = 1.28±0.46
Spergularia marina (L.) Griseb.	35.2-41.7 =38±1.22	34.2-43.4 = 38.7±1.29	0.98	5.45-9.2 = 7.3±0.69	8.15-14.5 = 11±0.94	2.45-3.15 = 2.5±0.17
Tamarix aphylla (L.) H.Karst.	23.15-35.7 = 35.7±1.61	21.5-52 = 31.05±1.13	1.15	2.1-3.15 = 2.4±0.16	1.4-2.15 = 1.75±0.11	4.7-6.2 = 5.5±0.37
Trifolium alexandrinum L.	36.2-22.0 = 25.4 ±7.23	35.5-19.5 = 24.1±4.10	1.05	15-0.5 = 5.98±4.54	12.5-0.50 = 6.1±3.36	7.55-1.95 = 3.61±1.3

Key words: SE= Standard Error; Min= Minimum; Max= Maximum; M= Mean; µm= Micrometer; P= Polar diameter; E= Equatorial diameter

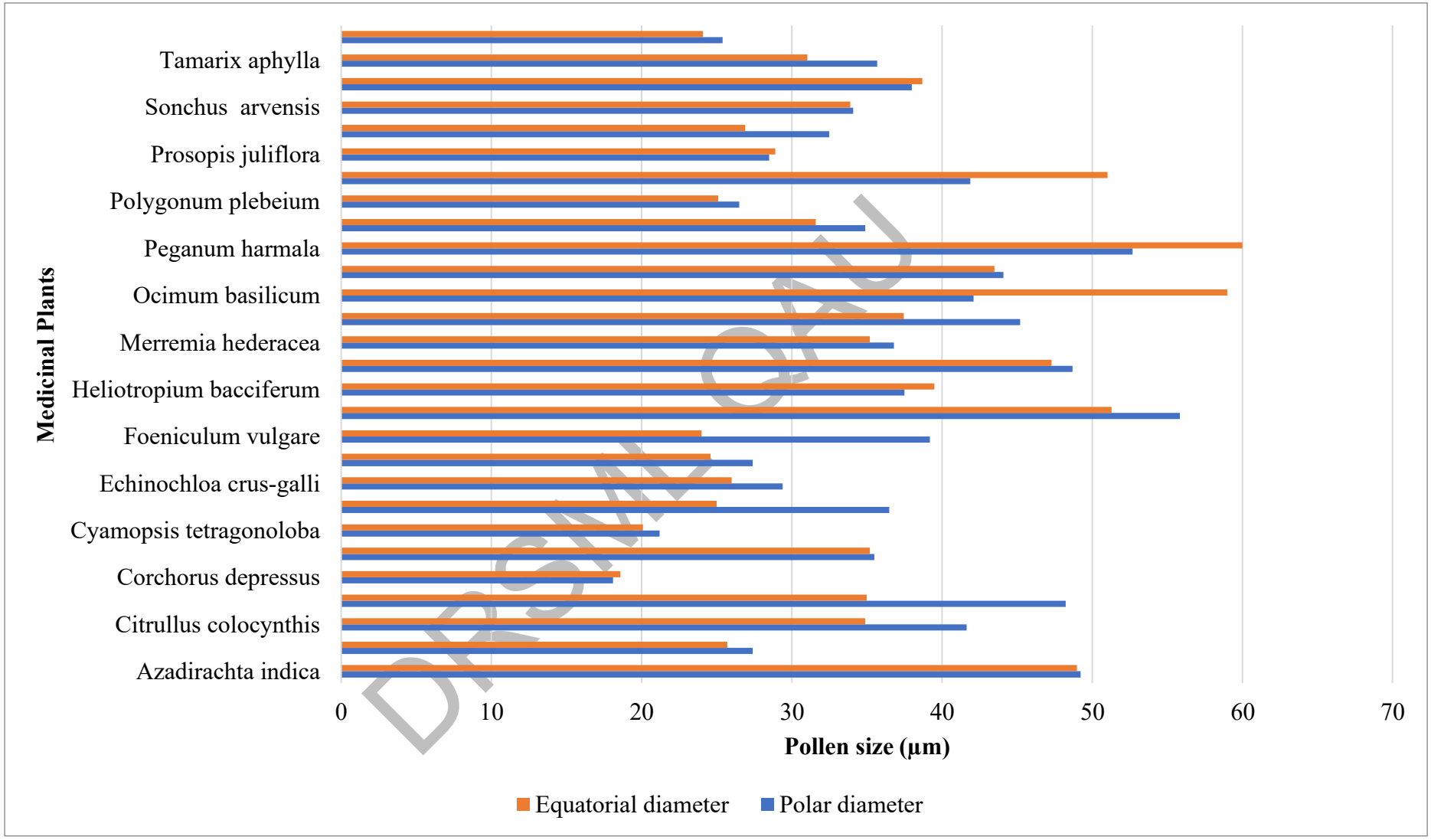


Figure 10. Polar and equatorial diameter variations of medicinal species

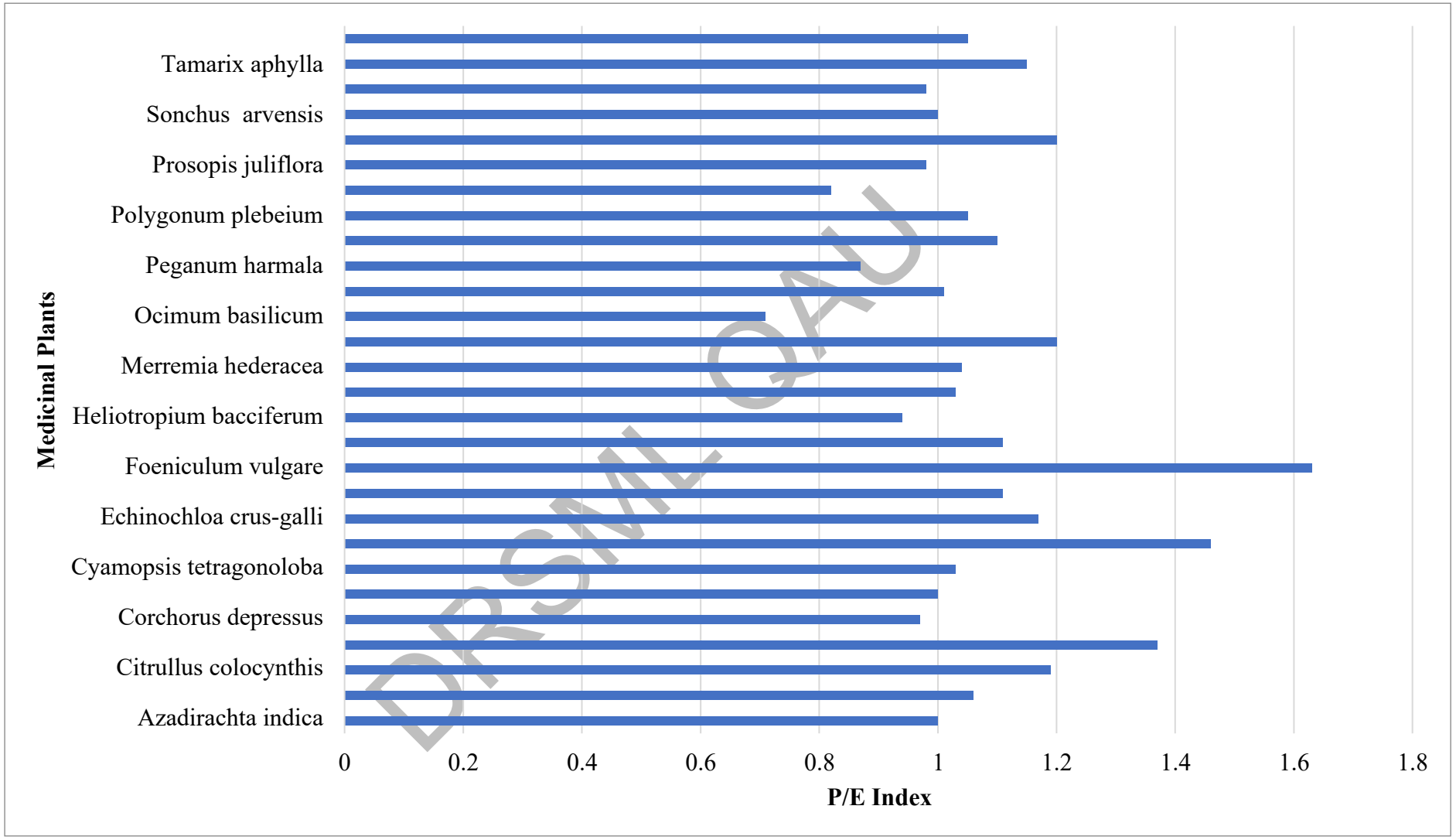


Figure 11. P/E ratio index among examined medicinal species

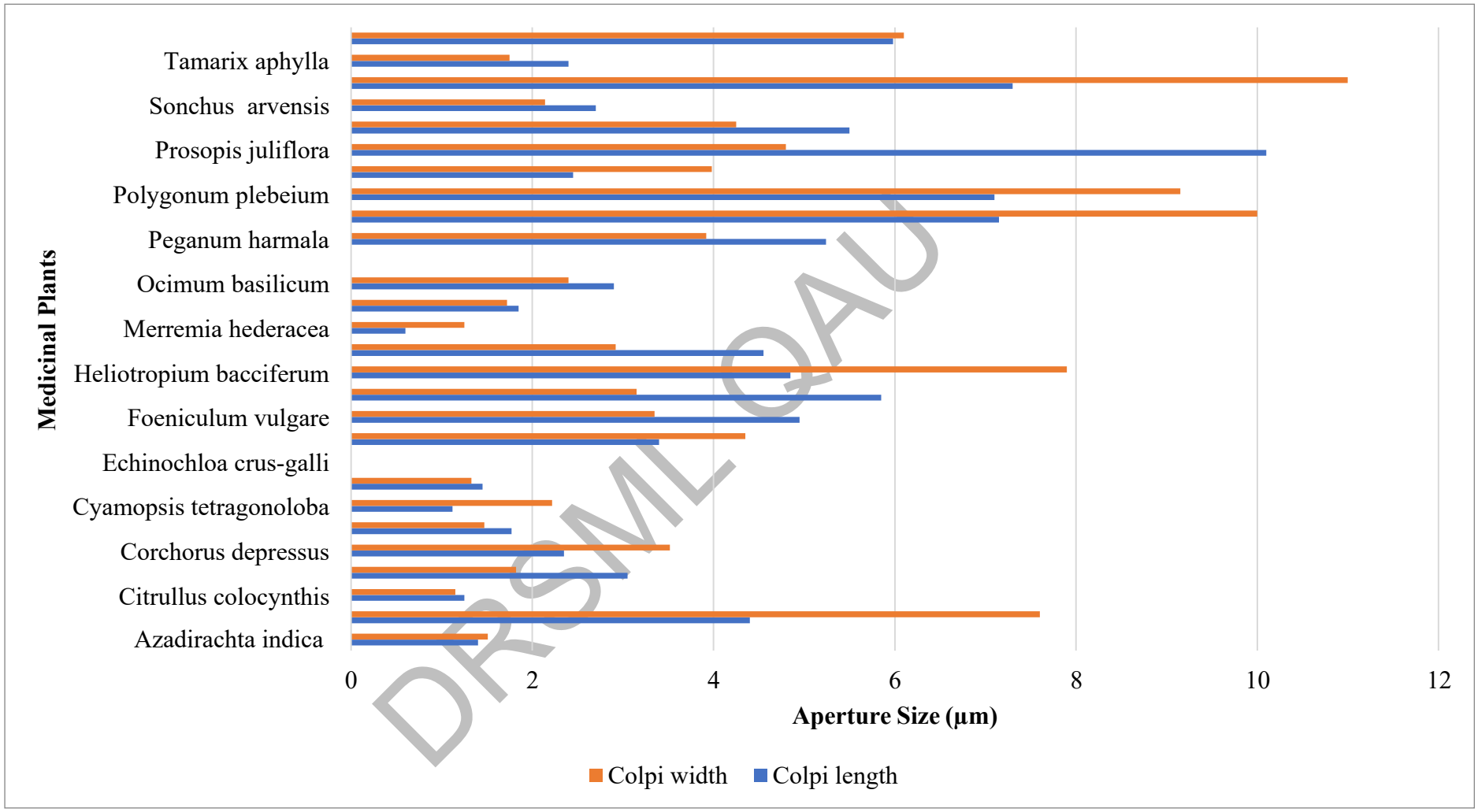


Figure 12. Graphical representation of aperture size variations in medicinal species

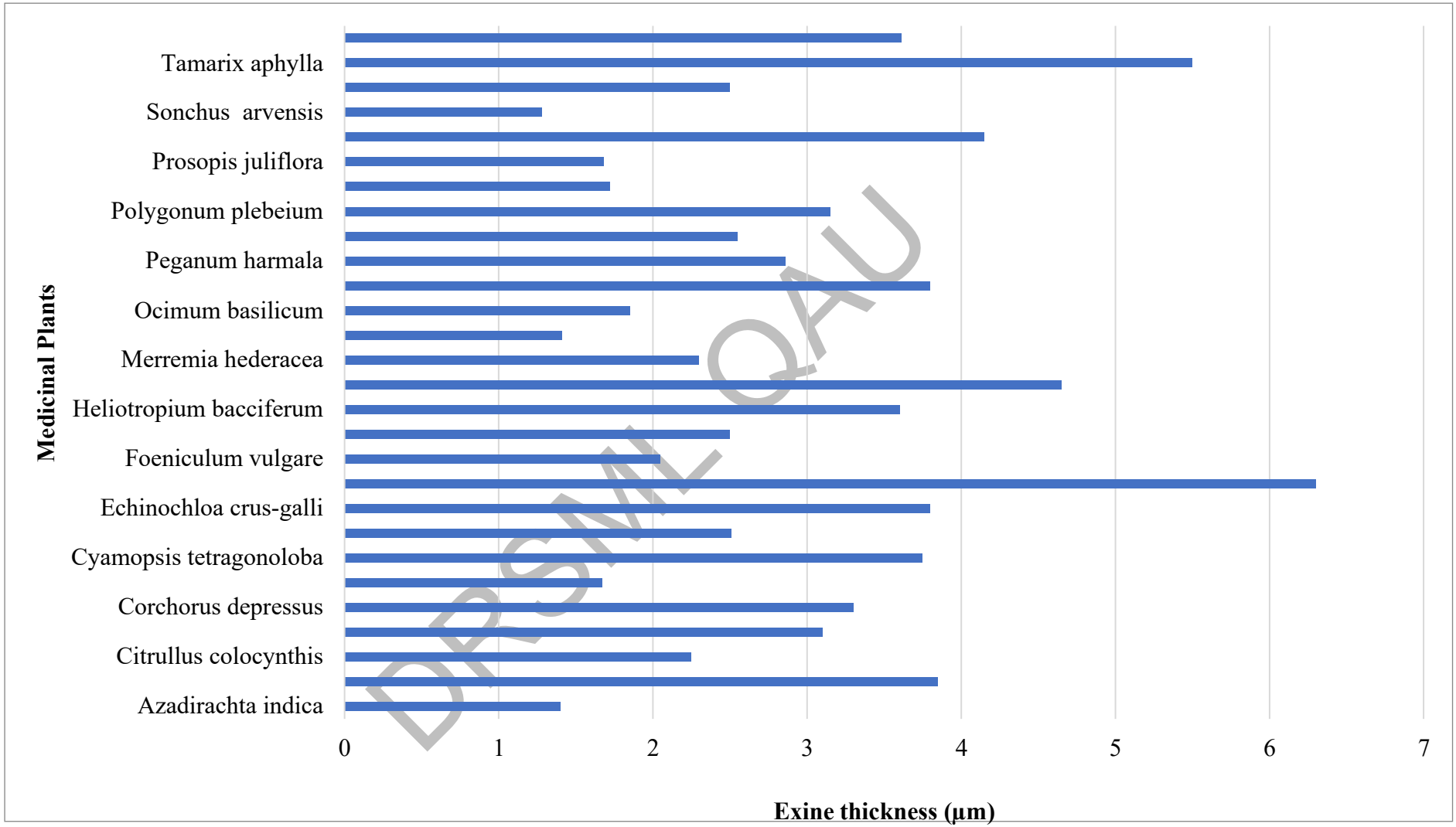


Figure 13. Graphical illustration of exine thickness variations in studied medicinal plants

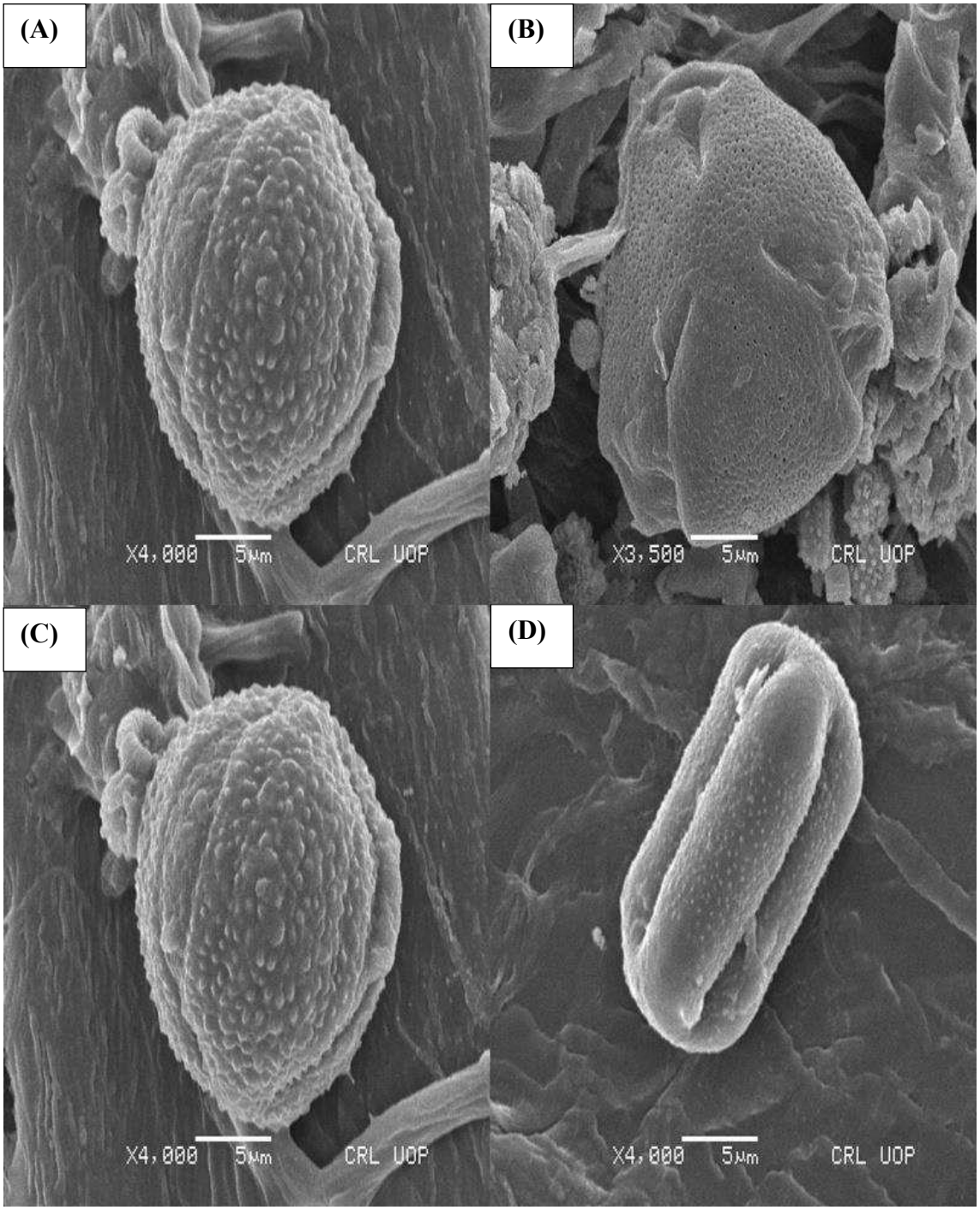


Plate 78. Scanning electron microscopy showing pollen view and sculpturing; (A) *Azadirachta indica* A. Juss. (B) *Citrullus colocynthis* (L.) Schrad. (C) *Cleome brachycarpa (*Forssk.) Vahl ex DC. (D) *Coriandrum sativum L.*

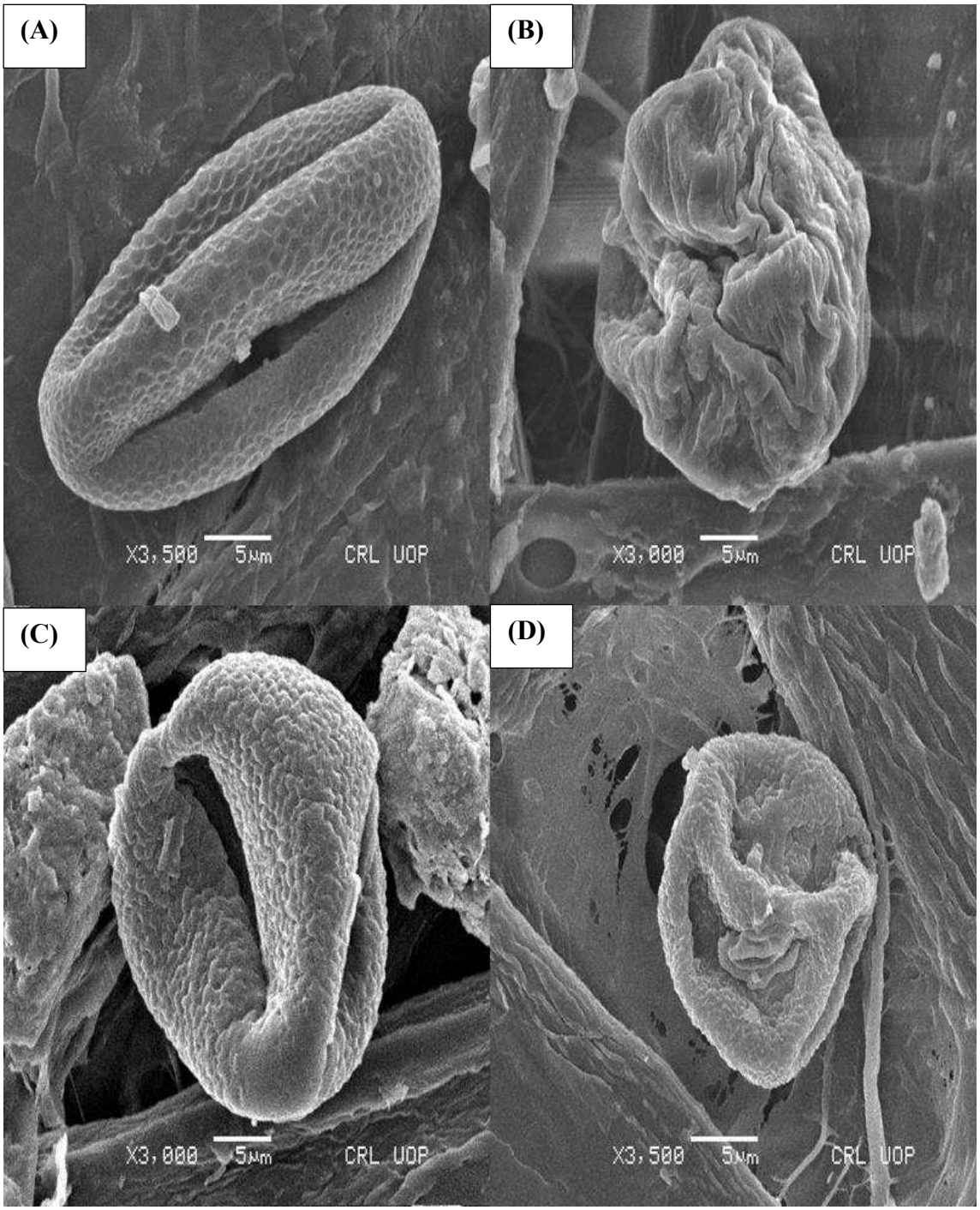


Plate 79. Scanning electron microscopy showing pollen view and sculpturing; (A) *Corchorus depressus*(L.) Stocks (B) *Cucumis sativus* L. (C) *Cyamopsistetragonoloba* (L.) Taub (C) *Cyperus rotundus* L.

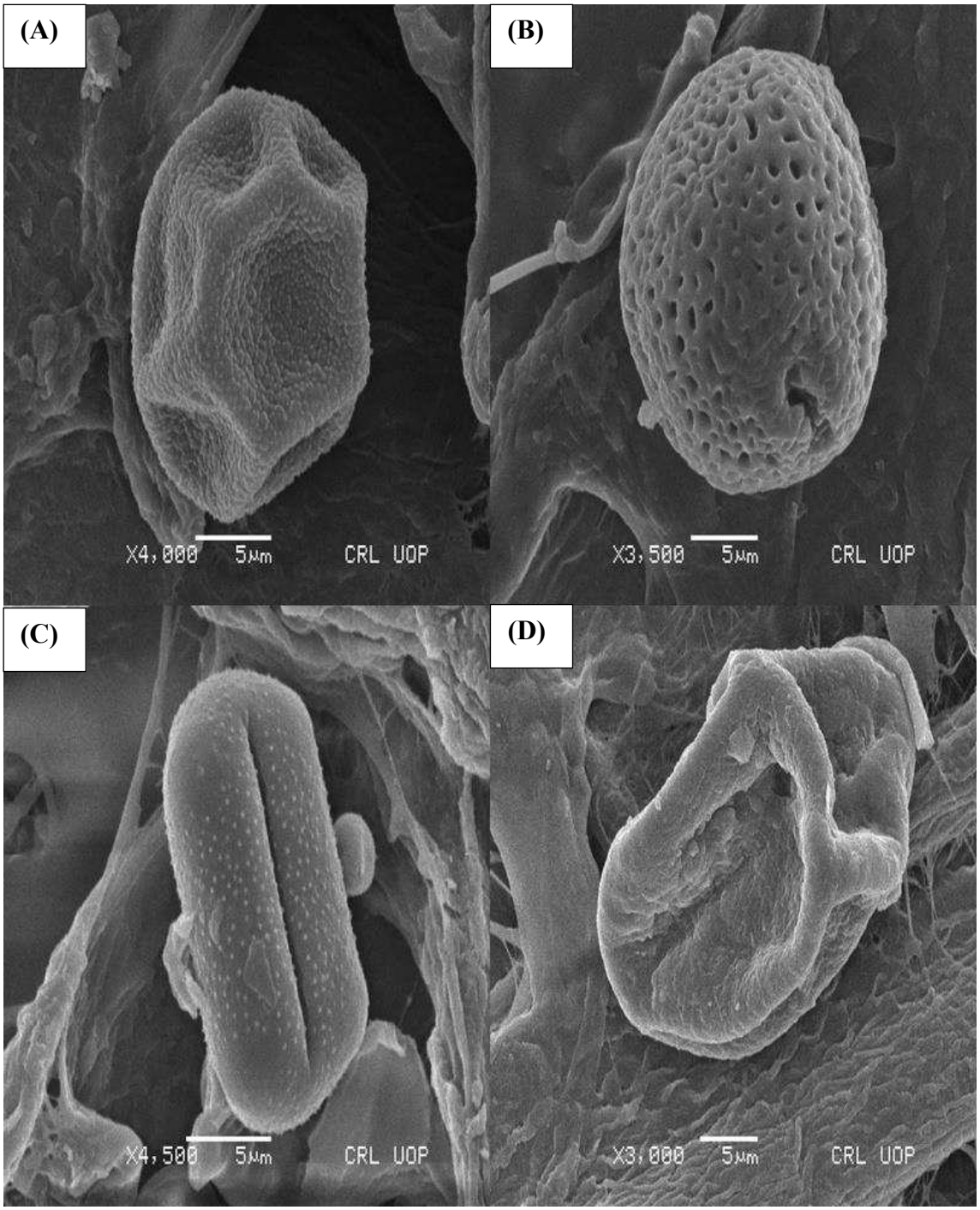


Plate 80. Scanning electron microscopy showing pollen view and sculpturing; (A) *Echinochloa crus-galli* (L.) P.Beauv. (B) *Enicostema hyssopifolium* (Willd.) Verd. (C) *Foeniculum vulgare* Mill. (D) *Heliotropium bacciferum* Forssk.

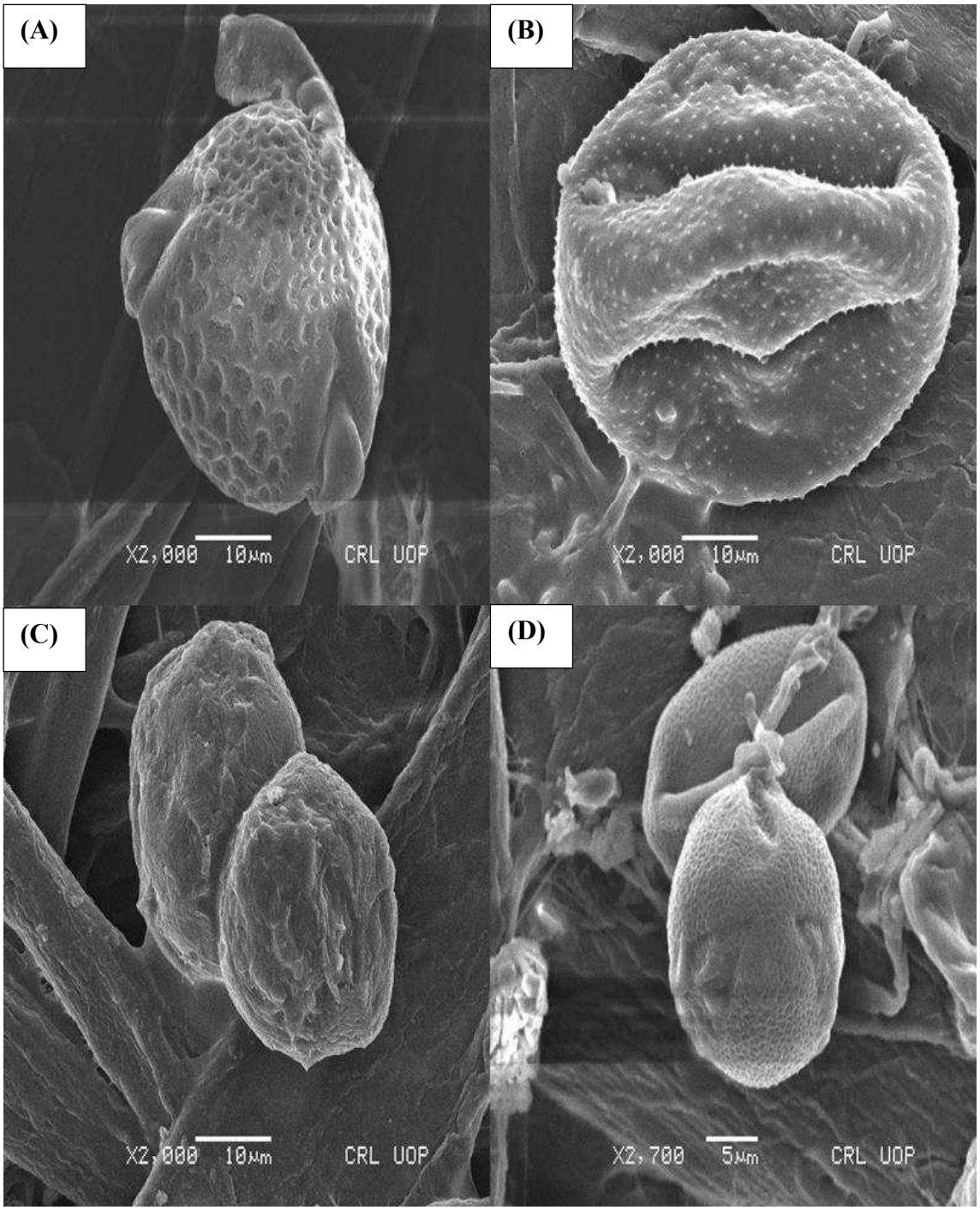


Plate 81. Scanning electron microscopy showing pollen view and sculpturing; (A) *Melilotus albus* Medik. (B) *Merremia hederacea* (Burm. f.) Hallier f. (C) *Nelumbo nucifera* Gaertn. (D) *Ocimum basilicum* L.

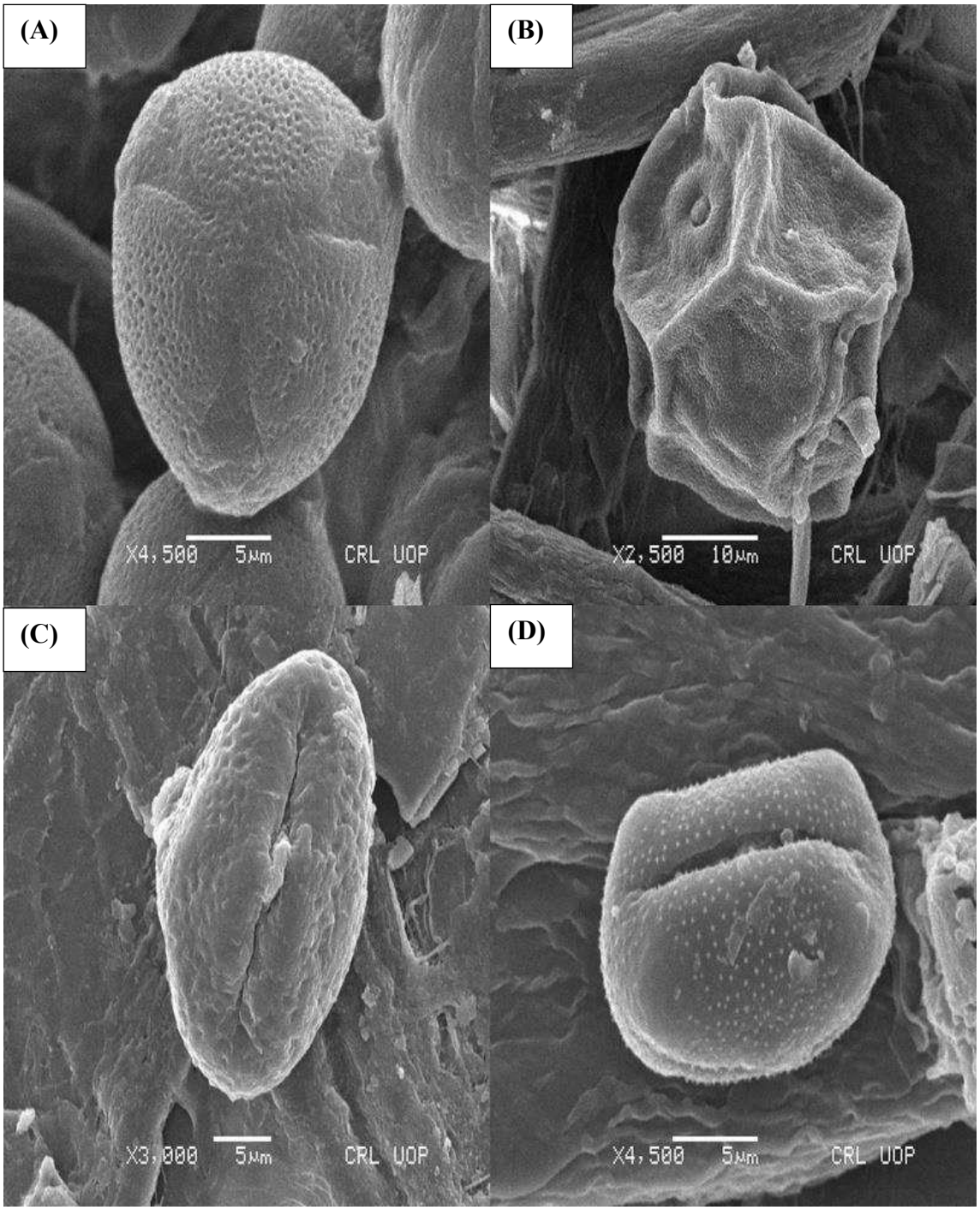


Plate 82. Scanning electron microscopy showing pollen view and sculpturing; (A) *Peganum harmala* L. (B) *Phalaris minor* Retz. (C) *Pithecellobium dulce* (Roxb.) Benth (D) *Polygonum plebeium* R. Brown, Prodr.

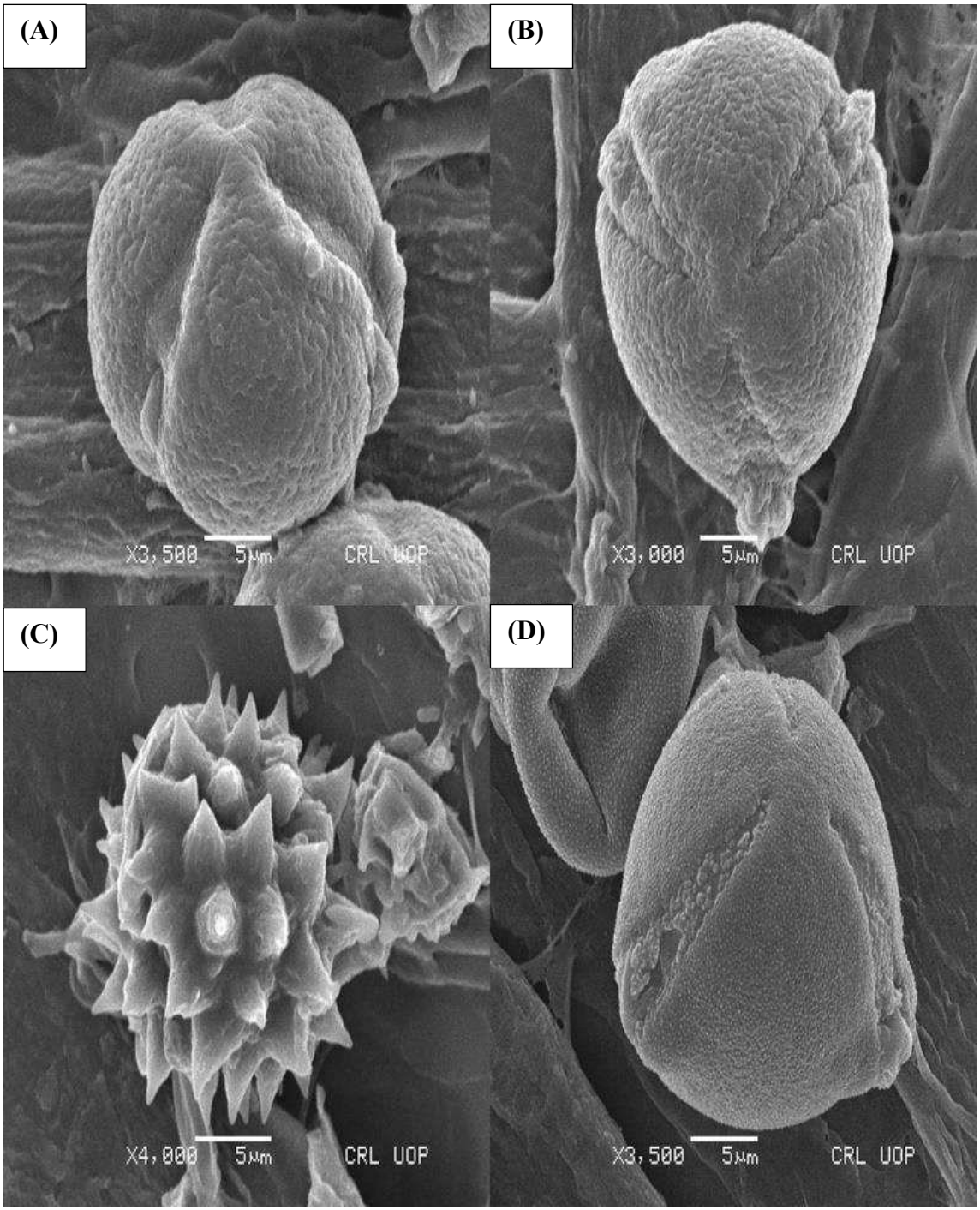


Plate 83. Scanning electron microscopy showing pollen view and sculpturing; (A) *Prosopis cineraria* (L.) Druce (B) *Prosopis juliflora* (Sw.) DC. (C) *Himalaiella heteromalla* (D.Don) Raab-Straube (D) *Solanum americanum* Mill.

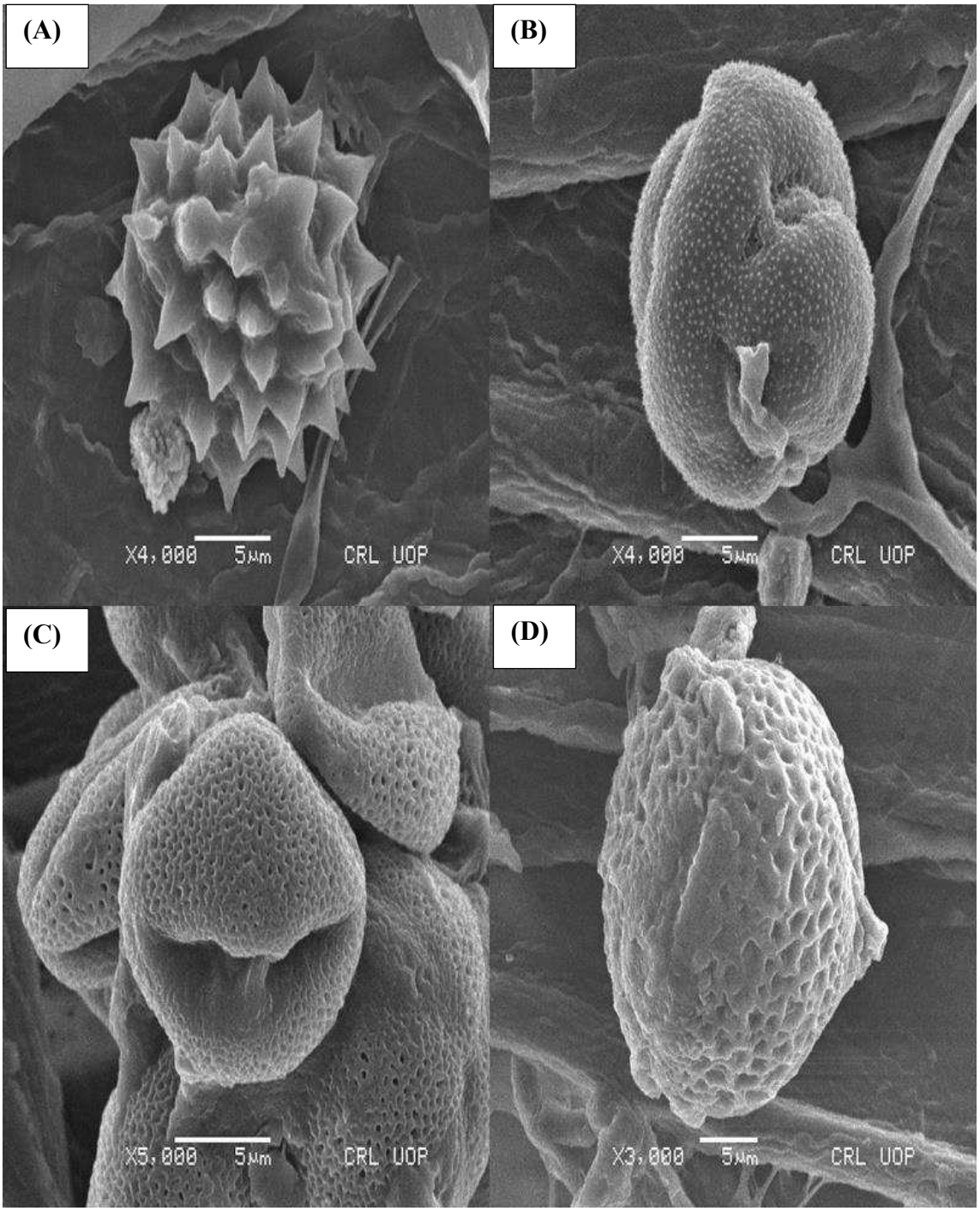


Plate 84. Scanning electron microscopy showing pollen view and sculpturing; (A) *Sonchus arvensis* L. (B) *Spergularia marina* (L.) Griseb. (C) *Tamarix aphylla* (L.) H.Karst. (D) *Trifolium alexandrinum* L.

Conclusion and Future Recommendations

6. Conclusions

The present study was confined to documentation of ethnobotany of medicinal plants commonly used as herbal medicine in the deserts of Southern region of Sindh Pakistan. Overall, the aims of the present project were: exploration of the diversity of important plant species commonly used the rural communities int the deserts of Southern Sindh; documentation of the sustainable ethnobotanical uses of medicinal plant species along with cultural recipes used for the treatment of veterinary disorders of livestock; documentation of the medicinal uses of important plant used as herbal drugs for the treatment of human rural populations, and analyses of data through ethnobotanical qualitative and quantitative techniques for sustainable utilization of precious medicinal plant species in the deserts of Southern Sindh. The results of the present study highlighted the most promising medicinal plants species used as sustainable source of herbal drugs used in the rural communities of deserts of Southern Sindh. Overall, 124 medicinal species used for the veterinary as well as human healthcare were reported from various communities of the Deserts of the Southern Sindh. In various regions of desert of southern Sindh, people use the medicinal plants species as sustainable source traditional medicine for curing various diseases.The most precious species used for the veterinary disorders were *Senna italica, Solanum surrattense, Fagonia bruguieri, Fumaria indica, Mukia medraspatana, Opuntia dillenii, Tamarix aphylla* and *Tribulus terrestris*. Most of the plant species used in the form of powder and decoction. For the treatment of human diseases, the diversity of plant species were used including *Cistanche tubulosa*, *Crotalaria burhia* , *Euphorbia hirta, Senna italica* and *Calligonum polygonoides*. The results of the present study indicate that deserts have rich diversity of Leguminous and Amaranthaceous species commonly used in treatment of diseases. It is concluded that the diversity of medicinal plant species is an important source of primary healthcare. The importance of medicinal plant species as sustainable source of herbal medicine may contribute to the development of rural development of the community. management, conservation, and sustainable use of medicinal flora in deserts in Sindh. The present study highlights the baseline data for further experimental elucidation and validation through phytochemical and pharmacological research, which could be of develop interest in the design of sustainable development of new herbal drugs based upon traditional recipes.

Furthermore, the evidence of these folk uses coupled with high ethnobotanical indices could provide the clues for further sustainable drug discovery development from new medicinal resources. In addition, species with only a few documented traditional uses may be further explored for preservation of traditional knowledge to them.

5. Future Recommendations

The present study highlights the need of proper attention on the medicinal plant diversity of deserts regions of Pakistan with special emphasis on deserts of Southern region of Sindh. Following are some major recommendations that may undertake in future.

- Detailed information should be focused on the documentation of species with respect to their uses and herbal recipes.
- New trends in the field of ethnobotany should be introduced by involving the rigorous data analysis.
- Ethnobotanical databases should be developed from where one may select species of interest for aimed study.
- For more detailed studies, the selection of plant species based on the most common uses should be selected for further experimental analysis.
- The contribution of local people should be highlighted and appreciated for conservation and sustainable use of plant diversity of deserts of Sindh and Intellectual property rights of local should be implemented for their active in community.
- Local people should be involved for conservation of species and preservation of traditional knowledge associated with species.
- Priority species having risks of survival should be selected for conservation strategies.

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Project Outcome

Research Papers Submitted

1. **Amir Hussain**, Muhammad Zafar, Mushtaq Ahmad, Shazia Sultana, Ghulam Yaseen, Salman Majeed, Jamil Raza. 2021. Scanning microscopic investigation of palyno- morphological features of *Apis florea* of Pakistan. Apidologie.

2. **Amir Hussain**, Muhammad Zafar, Mushtaq Ahmad, Shazia Sultana, Ghulam Yaseen, Salman Majeed, Jamil Raza, Maimoona Birjees. 2021. Ethnobotanical Exploration of Medicinal Plants Diversity in Southern Deserts of Sindh, Pakistan Acta Ecologica Sinica. (Under Review)
3. **Amir Hussain**, Muhammad Zafar, Mushtaq Ahmad, Shazia Sultana, Ghulam Yaseen, Salman Majeed, Jamil Raza. Pollen Diversity among Medicinal Plants via Scanning Electron Microscopy from the Southern Deserts of Sindh. Microscopy Research and Techniques. (Under Review)

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ETHNOVETERINARY USES OF MEDICINAL PLANTS AS HERBAL DRUGS FOR SUSTAINABLE LIVESTOCK IN SOUTHERN DESERTS OF SINDH PAKISTAN

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Abstract

The southern desert of Sindh, Pakistan is considered as green desert in the World due to rich diversity of medicinal plants and livestock production where ethnoveterinary medicines (EVM) are commonly practiced. Currently, this region is facing famine and natural disaster resulting in mortality of livestock. The present study was aimed to document and analyze the ethnoveterinary herbal recipes made from precious medicinal plants species. Data was collected through field surveys through opened questioners, semi structure interviews, group discussion and personal observation during field survey; and analyzed through quantitative indices such as relative frequency of citation (RFC) and the use value (UV); and to describe the preferred plant species, methods of preparation and plant part used. The data was collected from 225 informants including 145 animal experts and 80 local people. In total, 34 plant species belonging to 19 plant families were reported. Themost preferred species were *Senna italica, Phyla nudiflora, Solanum surrattense, Fagonia bruguieri* and *Asphodelus tenufolius*. The frequently reported plant part used were whole plants (31%) while less used was latex and bark (1%). The frequent mode of utilization was decoction (27%) while least was extract and juices (1%). The UV varied from 0.052 (*Fagiona bruguieri*) to 0.013 (*Capparis spinosa*) whereas the value of RFC ranged from 0.052 (*Senna italica*) to 0.014 (*Amaranthus viridis*). The present study would offer baseline data for clinical research in veterinary sciences. Ethnoveterinary data documented in the present study could offer an extraordinary background for conducting studies intended at implementing clinical phytotherapy research for livestock healthcare and production. It is recommended that plant species with high citations, quantitative indices values and preferred by pastoralists should be studied for phytochemical and pharmacological properties for future drug discovery development.

Key words: Pharmacology, Veterinary Sciences, Drug discovery, Medicinal plants, Indigenous knowledge.

Introduction

The deserts of Southern Sindh-Pakistan face famine and natural disaster resulting mortality of livestock. In deserts, livestock is important source of livelihood of local people. Globally, medicinal plants have been utilized as ethnoveterinary medicines among many indigenous communities and traditional healthcare systems for centuries (Tariq *et al*., 2014; Najeebullah *et al*., 2021). Ethnoveterinary medicine (EVM) describes the folk recipes, indigenous knowledge and norms and traditions of the local people regarding the health of livestock and other animals (Bhardwaj *et al*., 2013). It is reported that EVMs are considered as cheapest alternative medicine as compare to other forms of medications (Benítez *et al*., 2012). The most of the EVMs, are based on traditional belief and uses practiced over a time by pastoralists, shepherds, rural farmers and local people for the healthcare and livelihood of livestock (Sani & Gray, 2004). Among various countries, Ethiopia is considered for the highest livestock population production (Chamberlin & Schmidt, 2012). It is reported thatlivestock growth and production shares major part of the Ethiopian agriculture and represent about 40% of the totalagriculture (Giday & Ameni, 2003). Like Ethiopia, the Deserts of Sindh -Pakistan are also one of the biggest communities with livestock production and rural population worked as pastoralists. Livestock is consideredas major source of economy and livelihood in the desert region of Sindh- Pakistan but its productivity and sustainability are relatively poor as compare to rest of the world. Various factors such as poor health conditions, high morbidity and mortality rate; and available facilities are responsible for the low in economic growth productivity (Kidane *et al*., 2014; Monteiro *et al*., 2011).

In developing countries, the EVMs are frequently used in the management and cure of various livestock diseases (Scantlebury *et al*., 2013). In underdeveloped countries, about 90% of health care of livestock population depend up on plant-based recipes (Van Wyk & Prinsloo, 2018). In the desert populations of the Sindh most of the pastoralists and farmer use medicinal plants as livelihood and health care of livestock. Currently, the ethnoveterinary knowledge and practices are affected by various factors such as loss of traditional knowledge, degradation of culture, loss of plant resources and fast shift in trend from rural to urban life (Giday *et al*., 2009; Yineger & Yewhalaw, 2007; Shinwari *et al*., 2020). It is also notable that the knowledge of EVMs is transferred from one generation to upcoming generation but this wealth of knowledge is prone to loss due to improper documentation of ethnoveterinary knowledge and practices through oral tales (Birhanu & Abera, 2015; Mekelle, 2012). Thus, this loss will be continued unless the useful ethno-traditional practices are preserved, properly documented, and analyzed, for future generation and research.

The most of livestock farmers in deserts of Pakistan are poor and own averagely 5 to 6 animals per family (Hassan *et al*., 2014) and cannot afford expensiveallopathic drugs that finally lead to various problems in livestock and ultimately affects economic development of local people. In the desert populations, the EVMs can be used as alternative medicine for treating diseases in livestock and other grazing animals. The EVMs can help in improvement in livelihood and economic uplift of