Ethnobotanical, Phytochemical, and Biological Study of Tamarix Aphylla in Tehsil Paroa, District Dera Ismail Khan

Muhammad Matiullah[1], Urooj Gul[2], Kashaf Zahra[3], Naimat Ullah[4], Nasr Ullah Khan[5], Sumia Ali[6], Muhammah Waqas[7]

[1,2,3,6,7.] M. Phil Botany students, Institute of Biological Sciences, Gomal University, Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan
[4,] Assistant Professor, Institute of Biological Sciences, Gomal University, Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan
[5,] Assistant Professor, Department of Plant Breeding & Genetics, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan, Email: nasrkhanpbg@gu.edu.pk (Corresponding Author)

Abstract

Tamarix aphylla, a plant species native to Tehsil Paroa in District Dera Ismail Khan, KPK, Pakistan, has long been embedded in the local culture and traditional medicine practices. This study presents a comprehensive exploration of the ethnobotanical, phytochemical, and biological attributes of T. aphyla in this region. Extensive field surveys and interviews with local communities revealed a rich tapestry of traditional knowledge. T. aphyla finds diverse applications, including medicinal uses for ailments ranging from digestive disorders to dermatological conditions. The plant also holds cultural significance in rituals and ceremonies. Plant specimens were meticulously collected and subjected to extraction processes. Phytochemical screening unveiled the presence of various secondary metabolites, including alkaloids, flavonoids, terpenoids, tannins, and phenolic compounds. Advanced analytical techniques further elucidated specific chemical constituents. Biological assays showcased promising activities of T. aphyla extracts, including potent antimicrobial properties against clinically relevant pathogens. These findings underscore the value of Tamarix aphylla in the traditional pharmacopoeia of Tehsil Paroa and warrant further exploration of its potential in modern medicine. This study contributes to the preservation of Indigenous knowledge and offers a foundation for future drug development endeavors.

Keywords: Phytochemical analysis, Secondary metabolites, Biological activities, Antimicrobial properties, Tamarix aphylla

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INTRODUCTION

Tamarix aphylla, commonly known as "Athel pine" or "Athel tamarisk," is a shrub or small tree belonging to the Tamaricaceae family. It is native to arid and semi-arid regions of Asia and North Africa. Tamarix species are adapted to harsh environmental conditions and are often found in saline soils and along riverbanks (Mandal *et al.*, 2010). In the context of ethnobotanical studies, *Tamarix aphylla* may have traditional uses among local communities, such as medicinal applications, fuelwood, fodder for livestock, or other cultural uses. *Tamarix aphylla* is notable for its ability to thrive in arid and saline environments, making it well-adapted to regions with challenging growing conditions. Its taxonomy places it among a group of plants known for their tolerance to salt and dry conditions (Makarewicz et al., 2021). Its adaptability to different environments could make it of interest for studying its potential ecological and socio-economic significance (Lemke *et al.*, 2022).

The phytochemical composition of *Tamarix aphylla* reflects its adaptation to arid and saline environments. These bioactive compounds not only contribute to the plant's resilience but also offer potential health benefits to humans. The major component of phytochemicals is flavonoids which are a prominent class of secondary metabolites found abundantly in *Tamarix aphylla* (Kuntal *et al.*, 2018). In *Tamarix aphylla*, flavonoids play crucial roles in adaptation to environmental stress and defense against pathogens, while also offering potential therapeutic effects for human health (Alhourani et al., 2018). *Tamarix aphylla* also contains tannins, which are polyphenolic compounds known for their astringent taste and ability to bind proteins. Tannins also contribute to the plant's resistance against herbivores and pathogens, playing a role in its ecological interactions (Deshmukh et al., 2018). Tannins exhibit broad-spectrum antimicrobial activity, making them valuable in combating bacterial and fungal infections. They also show potential antiviral activity, inhibiting viral replication and attachment to host cells (Sreenivasa et al., 2012). Besides flavonoids and tannins, *Tamarix aphylla* also contains phenolic acids, alkaloids and saponins playing an important role in human health (Działo *et al.*, 2016), Ali *et al.*, 2019).

Research into the pharmacological activities of *Tamarix aphylla* extracts continues to uncover new therapeutic applications for these natural compounds. In addition to their medicinal properties, the phytochemicals in *Tamarix aphylla* play essential ecological roles. They contribute to the plant's interactions with other organisms, including herbivores, pollinators, and soil microbes. Some phytochemicals deter herbivores and pathogens, while others attract beneficial insects or facilitate nutrient cycling in the soil (Strudley and Dalin, 2013; Han et al., 2013; Bedair et al., 2020). Understanding the phytochemical profile of *Tamarix aphylla* is crucial for harnessing its potential as a source of natural medicines and for conservation efforts aimed at preserving its unique ecological niche. Further research into the bioactivity and molecular mechanisms of these compounds will likely uncover new applications in medicine, agriculture, and environmental management. Phytochemical analyses of *Tamarix aphylla* could reveal the presence of bioactive compounds that may have implications for human health and well-being. This study was designed to investigate the ethnobotanical, phytochemical, and biological aspects of *Tamarix aphylla*, a plant species native to

Tehsil Paroa, District Dera Ismail Khan, KPK, Pakistan.

MATERIAL AND METHOD

Study Area

Dera Ismail Khan is located in the Khyber Pakhtunkhwa province of Pakistan. It is situated approximately at 31.8281° N latitude and 70.8986° E longitude. The elevation of Dera Ismail Khan ranges from approximately 165 meters (541 feet) to 305 meters (1,001 feet) above sea level. The city is located in a relatively low-lying area compared to the surrounding mountainous regions. Dera Ismail Khan is predominantly characterized by plains and relatively low hills rather than towering mountains. The Sulaiman Mountain Range lies to the west of the city, though the immediate vicinity of Dera Ismail Khan is more level (Figure 1). Dera Ismail Khan experiences a semi-arid climate. Summers are hot, with temperatures often exceeding 40°C (104°F) during the day. Winters are mild, with temperatures rarely dropping below freezing. The region receives low rainfall, mostly concentrated in the monsoon season (July to September). The vegetation in Dera Ismail Khan is adapted to the semi-arid climate. Natural vegetation includes thorny shrubs and sparse grasses, particularly in the drier areas. Cultivated plants include various crops such as wheat, rice, sugarcane, and vegetables.

Fig. 1 Map of the Dera Ismail Khan where the study was carried out.

Botanical identification

Botanical identification involves scientifically determining the species of a plant based on its morphological characteristics. This process was carried out in the Department of Botany at the Institute of Biological Sciences, Gomal University. Dr. Naimat Baloch, an Assistant Professor in the Department of Botany at Gomal University, played a crucial role in identifying and authenticating the *Tamarix aphylla*specimen. His expertise in botany and plant taxonomy ensured accurate species identification. A specimen of *Tamarix aphyllous* was deposited in the herbarium of Gomal University to obtain a voucher ID. Herbarium specimens are essential for scientific research and education, providing a physical record of plant species for future reference and verification.

Ethnobotanical data collection

The study focused on Tehsil Paroa in Dera Ismail Khan, where semi-structured interviews were conducted with various groups, including elderly individuals, traditional healers (Hakims), and local plant sellers who specialize in medicinal plants. Semi-structured interviews were used to gather ethnobotanical information about *Tamarix aphylla*. Participants were asked about traditional uses of the plant, local names and cultural significance, images and descriptions of the plant and diseases or health conditions treated using this plant.

Plant sample collection and preparation

Selection of plant material

Appropriate plant parts (leaves, stems, roots, flowers, fruits, etc.) were chosen based on the target compounds (e.g., alkaloids, flavonoids, essential oils). Samples were collected from healthy plants, avoiding damaged or diseased parts.

Cleaning and Washing

The collected plant materials were rinsed thoroughly with distilled water to remove soil, dust, and other contaminants. Collected samples were pat-dried with

paper towels and material was allowed to air-dry.

Size Reduction

Depending on the analysis method, plant materials were chopped and ground into smaller pieces, using a mortar and pestle or a blender to obtain a fine powder.

Drying

Some analyses require dried plant material to prevent the degradation of compounds during storage or extraction. Therefore, plant materials were dried using an oven or a dehydrator at a low temperature (e.g., 40-50°C) until crisp.

Extraction of Phytochemicals

Plant extracts were obtained through maceration in ethanol for further use of these extracts for phytochemical screening. To detect alkaloids, the extract was treated with dilute hydrochloric acid and then tested with Dragendorff's reagent or Mayer's reagent for precipitation. The presence of flavonoids was tested using methods like the Shinoda test, which involves the addition of magnesium ribbon and concentrated hydrochloric acid to the extract. Tannins were detected by adding ferric chloride solution to the extract, resulting in the formation of a blue-black or greenish-black color. Saponins were identified by observing the formation of a stable foam upon shaking the extract vigorously with water. The presence of glycosides was tested by treating the extract with concentrated sulfuric acid, followed by the addition of an aqueous solution of sodium nitrite. Terpenoids were detected using the Salkowski test, where the extract was mixed with chloroform and concentrated sulfuric acid, resulting in the formation of a reddish-brown coloration at the interface. The presence of phenolic compounds was determined by adding a dilute ferric chloride solution to the extract, resulting in the formation of a colored complex. The appearance of specific color changes, precipitates, or foam indicated the presence of respective phytochemical classes in the plant extracts. Observations and results from the qualitative tests were recorded systematically, documenting the presence or absence of different phytochemicals in the *Tamarix aphylla* extracts.

Determination of Antimicrobial Activity

Pure cultures of the test microorganisms (*Candida albicans, Staphylococcus aureus, Escherichia coli, Proteus mirabilis, Klebsiella pneumonia* and *Shigella flexneri*) were obtained from the Department of Pharmacy, Gomal University, D.I. Khan. Standardized inoculum was prepared for each bacterium. Antimicrobial susceptibility testing was conducted using methods like disk diffusion assay (Kirby-Bauer method). Agar plates or broth media supplemented with the appropriate nutrients were prepared. Methods like measuring zones of inhibition (for disk diffusion assay) or determining minimum inhibitory concentration (MIC) values (for broth micro-dilution assay) were used to quantify antimicrobial activity. Positive controls were included for comparison: ampicillin (100 mg/mL) served as a positive control for antibacterial activity, while nystatin (100 mg/mL) served as a positive control for antifungal activity.

Statistical Analysis

The experiments were conducted three times independently, and the results for each sample were documented as mean values ± standard deviation (n = 3). Statistical analysis was performed using MS Excel and SPSS software (version 21). In all analyses, differences were deemed statistically significant at a p-value < 0.05.

RESULTS

Ethnobotanical information-based collection of *Tamarix aphylla*

A total of 52 people were interviewed, comprising 40 older men of age more than 60 years, 6 Hakims, and 6 local herbal sellers. Respondents confirmed multiple local names for the plant species and noted that the optimal time for wild plant harvest is in the spring before or during flowering. The ethnobotanical survey findings indicated that the identified plants were associated with the treatment of 18 different diseases and disorders. Nearly all respondents were familiar with these species, affirming their widespread use within local communities for various human ailments. Most respondents reported personal use of these plants at least once and recommended them to neighbors and friends. Notably, the same plant parts were often utilized to address different conditions; for instance, the leaves of *Tamarix aphylla* were used for fever, wound healing, jaundice, and rheumatism. Overall, the use values (UVs) for these plants were generally high (Table 1).

Table 1. Information of selected plant (*Tamarix aphylla*) in the study area of Tehsil Paroa, D.I. Khan.

Scientific name/Family	Voucher number	Local name(s)	Growth habit	Part used and medicinal use(s)
Tamarix aphylla (L.) Tamaricaceae	KH-190	Khagal	Tree	**Leaves:** - Decoction used for fever, measles, jaundice, and rheumatism. - Rubbed externally on the head to relieve headache and on legs as antirheumatic. - Smoke for wound healing. **Bark:** - Decoction to treat hepatitis. - Powder applied for eczema and other skin diseases. - As a poultice on wounds. **Roots:** - Paste applied directly on the wound to treat infections. - Decoction for stomach ache. **Aerial parts:** - Decoction used as a diuretic. - Maceration in water used to treat headache and hypertension. - Infusion or paste used to alleviate rheumatism. **Roots:** - Decoction used to relieve kidney stones. - Chewed for toothache and to relieve headache. - Paste is applied on the face to remove acne. - Infusion (drink) for diarrhea and chronic chest pain.

Extraction Yield and Phytochemical Analysis

The ethanol extraction yield of *Tamarix aphylla* bark was found to be 12.3% and 5%. The results of the initial phytochemical screening, depicted in Figure 2, indicated the presence of alkaloids, glycosides, saponins, triterpenes, tannins, and flavonoids in varying abundance levels across the three plant extracts. Notably, all tested extracts showed negative results for anthraquinones (Figure 2).

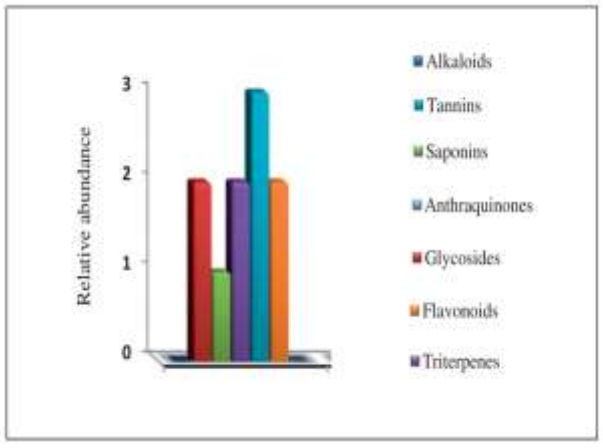

Fig 2 Phytochemical profile of the ethanolic extracts of the *Tamarix aphylla*. **3**; abundant (heavy precipitate), **2**; fairly present (turbidity), **1**; slightly present; and **0**; absent (clear).

Antimicrobial activity of *Tamarix aphylla*

Antimicrobial analysis tests revealed a significant inhibitory effect of *Tamarix aphylla* extract against *C. albicans, S. flexneri, S. aureus, K. pneumonia, E. coli* and *P. mirabilis*. Based on the size of the zone of inhibition, the inhibitory effect of *Tamarix aphylla* extract was more prominent in E. coli and *S. flexneri* as compared to other pathogens (Fig. 3).

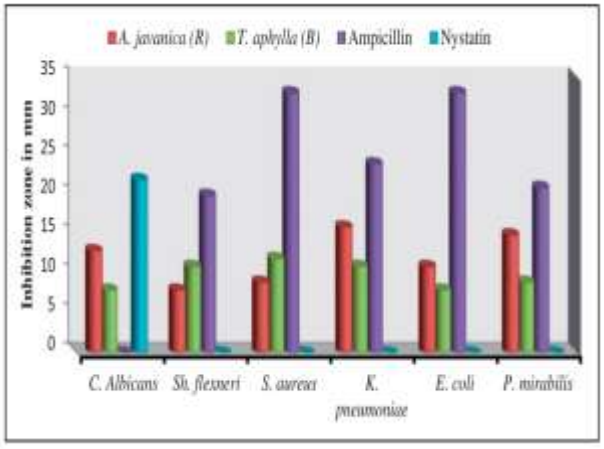

Fig. 3 Zone of inhibition of *Tamarix aphylla* extracts against test pathogens.

DISCUSSION

The Use Value (UV) index was utilized in this study to evaluate the significance of Tamarix aphylla within the local population of the study area. This index is valuable for analyzing the utilization of a specific plant species and for comparing different plants within the same sample (Andrade-Cetto & Heinrich, 2011). Overall, the Use Values (UVs) for Tamarix aphylla were notably high, indicating extensive knowledge dissemination among informants regarding the medicinal importance and uses of these plants. Plants with higher UV values reflect greater usage by the local community and significant therapeutic potential against human health issues. Therefore, such plants merit further investigation into bioactive phytochemicals and other pharmacological activities. The ethnobotanical investigation revealed that these two plant species offer remedies for approximately 18 human diseases within the study area, positioning them as valuable medicinal plant species. Various parts of *Tamarix aphylla* are utilized to treat a range of disorders, including joint pain, skin ailments, and kidney problems.

Certain medicinal applications documented in this study align with those reported in existing literature. For instance, Arnebia javanica has been noted for its diuretic properties (Arbab et al., 2016) and its use in acne treatment. External application of *Tamarix aphylla* has been associated with wound healing and addressing skin conditions (Akhlaq & Mohammed, 2011; Ahmed et al., 2009; Suleiman 2019). However, discrepancies were observed in other medicinal uses. For example, the use of *Tamarix aphylla* root decoction for stomach aches conflicts with previous records indicating its use for tuberculosis, smallpox, leprosy, and contagious ailments (Ali et al., 2019). A substantial proportion of local respondents in previously reported ethnobotanical surveys revealed the use of *Tamarix aphylla* leaves to alleviate joint pain, headache, and rheumatism, which may be attributed to phytochemicals present in *Tamarix aphylla* leaves. Respondents in our survey also revealed the use of *Tamarix aphylla* leaves and bark by local people to alleviate joint pain, headache, and rheumatism. This is further supported by the phytochemical analysis of *Tamarix aphylla* bark extract (Figure 2) indicated notable levels of tannins, moderate amounts of flavonoids and glycosides, and the absence of alkaloids and anthraquinones, consistent with previous findings (Suleiman et al., 2019; Tako et al., 2020).

Regarding antimicrobial activities, the root extract of *Arnebia javanica* exhibited weak to moderate activity against all tested pathogens. Similarly, *Tamarix aphylla* bark extract demonstrated weak to moderate antimicrobial activity against the tested pathogens (Figure 3), aligning with previous findings (Umair et al., 2019; Vaou et al., 2021). These results suggest that the medicinal properties of these species may be attributed to biological activities beyond antimicrobial effects. The valuable ethnobotanical knowledge regarding medicinal plants, such as *Tamarix aphylla* and their health benefits, remains largely untapped in Tehsil Paroa, District Dera Ismail Khan. This study has compiled essential information on the ethno-pharmacological and folklore uses of *Tamarix aphylla* employed by the local inhabitants to address human ailments.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

AUTHORS CONTRIBUTION

Nasr Ullah Khan and Naimat Ullah conceived the idea, designed the study and

drafted the manuscript. Muhammad Matiullah conducted the experiments and collected and analyzed the data.

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