Research Article

Phytosociology of Subtropical Chir Pine Forest of Matta Forest Subdivision

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Abstract | A study was carried out to quantitatively describe the phytosociological characteristics of the Chirpine forest in the Matta Forest subdivision of Swat valley. The phytosociology of the study area has been analyzed using a total of 35 sample plots in the field to provide a detailed description and analysis of the plant species present in the ChirPine forest. The study area is characterized by a dominant presence *of Pinus roxburgii,* accounting for a substantial 73.0% of the total trees. However, this forest is not a monoculture; it boasts a diverse array of tree species. *Robinia pseudacacia*, *Pyrus pashia, Alianthus altissima,* and *Eucalyptus camaldulensis* make up significant portions of the forest at 6.4%, 0.1%, 4.6%, and 4.3%, respectively. Other species like *Prunus domestica, Pyrus communis, and Olea* spp. contribute as well, at 1.0%, 1.4%, and 6.9%. The study also identified key soil factors influencing species distribution in the area, which included soil pH, electrical conductivity, moisture content, and organic carbon. These factors had average values of 7.04, 4.83 ms/cm, 6.11%, and 2.21%, respectively. The Matta subdivision of Swat valley has a notable prevalence of pinus roxburghii, which emerges as the predominant coniferous species within the chir pine zone of the subdivision. The forest ecology is primarily threatened by the conversion of forest land to agriculture and the illicit harvesting of trees for fuel wood and construction reasons. Implementation of strict regulations and community-based forest management to combat the threats of land conversion and illicit tree harvesting, while promotion of reforestation and alternative energy sources in the Matta subdivision of Swat Valley are highly recommended.

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Introduction

Plants with similar characteristics and ecological requirements tend to associate, forming distinct plant ecological groups (Braun-Blanquet, 1983). Plant communities are composed of one or several ecological groups, each with distinct characteristics (Khademi and Babaee, 2009). Plant species within ecosystems have encountered environmental changes over their ecological and evolutionary timelines. The pace and extent of these changes significantly affect the ability of plant species to adapt, especially those with limited genetic diversity and narrow ecological ranges (Critchfield, 1984; Davis, 1992). The structure, composition, and functioning of forest ecosystems vary significantly due to environmental and anthropogenic factors (Gairola *et al*., 2008; Timilsina *et al*., 2007).

The diversity of vegetation is shaped by various environmental factors, including water availability, temperature, solar radiation, and air current flow velocity (Hinterlang, 1992). Understanding these factors is crucial for assessing the ecological expression within a habitat (Khan *et al*., 2012). Ecological diversity is a vital benchmark for assessing ecosystem health, as it encompasses the variety of species, habitats, and processes that underpin ecosystem functioning (McGardy-Steed and Morin, 2000).Investigating how species diversity changes along environmental gradients has become a key focus of ecological studies in the latest decade (Currie and Francis, 2004).

Soil characteristics, including effective depth, concretion presence, water table proximity, drainage, and fertility, play a crucial role in shaping the floristic composition, structure, and productivity of native vegetation (Haridasan, 2000). Topography and soil composition are key abiotic factors driving plant physiognomic differentiation across diverse habitats, with significant implications for forest management and biodiversity conservation (Ehrlich, 1996). Edaphic and topographic factors (altitude and aspect) significantly influence community composition and structure (Ilyas *et al*., 2018). Haridasan (1992) suggested that edaphic factors, particularly soil moisture and composition, influence phytophysiognomy. Environmental gradients, such as topography and soil variables, shape vegetation structure (Ismail *et al*., 2019; Khadanga and Jayakumar, 2020).

Forest ecosystems display heterogeneous characteristics and functioning in response to interacting environmental and anthropogenic drivers (Gairola *et al*., 2008; Timilsina *et al*., 2007). The distribution and abundance of plant individuals are governed by habitat characteristics, temporal variability, and interactions with other plants (Khan *et al*., 2013). Geographical location, ecosystem productivity, evolutionary competition, and human-forest interactions underlie the observed variations in plant community composition and structure (Eriksson, 1996; Criddle *et al*., 2003). Thus, it is necessary to know about the driving environmental factors of an area which affect the plant species composition, distribution and community structure (Rahman *et al*., 2022; Ullah *et al*., 2022).

Phytosociology is a scientific discipline that examines the composition, development, dynamics, and interrelationships within plant communities (Mishra *et al*., 2012). Phytosociology studies the interdependence of vegetation and soil, where ecological conditions shape plant adaptation, revealing environmental characteristics through soil-plant relationships (Boggs, 2000). Phytosociological analysis uses multivariate statistics to study population trends, interspecies relationships, and vegetation structure, revealing responses to environmental factors (Ahmad *et al*., 2019; Dufrêne and Legendre, 1997). It is a valuable discipline with applications in environmental science, geography, ecology, conservation, and landscape science (Rieley and Page, 1990; Ewald, 2003; Biondi, 2011).

This research project has two primary objectives. First, it aims to study the phytosociology and species diversity of the Chir pine forest in the Matta Forest subdivision of Swat valley. This study involves analyzing the composition, organization, and spatial patterns of plant communities within this unique ecosystem, with a focus on understanding their distribution and relationships. The findings of this study will contribute to the development of informed ecosystem management and conservation approaches, grounded in the understanding of soil characteristics and plant distribution.

Materials and Methods

Study area

Matta tehsil is situated in Swat, Khyber-Pakhtunkhwa. Pakistan, its geographical coordinates are from 34° 36′ 59″ to 35° 44′ 51″ N Longitude and from 72° 29′ 52″ to 72° 09′ 52″ E Latitude. Tehsil Matta is a rural area with 100% rural population. It has a total area of 683 sq. km. Matta is a local word which means clay soil. It is located about 20 km from the central city of Mingora. Matta Subdivision is the largest country Tehsil of Swat district.

Sampling procedure and data collection

Data collection was conducted in the Matta subdivision of Swat valley, encompassing approximately 350 acres of planted Chir pine forests. A 1% sampling intensity was used, resulting

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in the selection of 35 sample plots. Each plot had a standardized size of 0.1 acres. Sample plots were randomly selected, beginning from lower elevations and progressing towards the tree line. This approach considered factors like spacing, tree population, size, density, crop variation, altitude differences, and slope, ensuring diversity in the dataset. The plots were either circular with an 11.3-meter radius or 20x20 meter squares, approximately equivalent to 0.1 acres in size. In each selected plot, the count of each plant species was recorded, along with geographic location and elevation using GPS. The slope of the plot was measured using a Clinometer, and soil samples were collected with a Soil Auger from plots showing species variations.

Soil samples were air-dried and sent to the soil lab for analysis. The following soil properties were examined:

Moisture content: Samples were oven-dried at 105°C for 6 hours, and moisture content was calculated using the formula: MC % = (Fresh weight - Oven dry weight) / Oven dry weight x 100.

Ash content: Oven-dried samples were heated in a muffle furnace at 450°C until they turned to ashes. Ash content was calculated using the formula: Ac % = (Oven dry weight - Ash weight)/ Oven dry weight x 100.

PH and electrical conductivity: PH was determined in a 1:5 soil-water suspension using a pH meter. Five grams of soil were mixed with 25 ml of distilled water and shaken for 30 minutes. The PH and electrical conductivity were measured using the pH meter.

Organic carbon: Organic carbon was estimated by multiplying the ash content by a factor of 0.58, as 100 kg of organic matter contains 58% organic carbon.

Results and Discussion

Specie composition

The sampled tree species included both broad leaves and conifers. The data revealed that in the study area of the Chir Pine forest, the tree species composition was characterized by a dominant presence of *Pinus roxburghii*, accounting for a substantial 73.0% of the total trees. This coniferous tree, also known as the longleaf pine or chir pine, played a central role in shaping the forest's ecosystem. However, the forest was not a monoculture; it boasted a diverse array of tree species. *Robinia pseudacacia*, *Pyrus pashia*, *Alianthus altissima*, and *Eucalyptus camaldulensis* made up significant portions of the forest at 6.4%, 0.1%, 4.6%, and 4.3%, respectively. Other species like *Prunus domestica*, *Pyrus communis*, and *Olea* spp. contributed as well, at 1.0%, 1.4%, and 6.9%, respectively. This diverse composition enriched the forest's biodiversity, providing habitat and sustenance for various wildlife species and contributing to the overall health and resilience of the ecosystem. The figure depicts the specie composition.

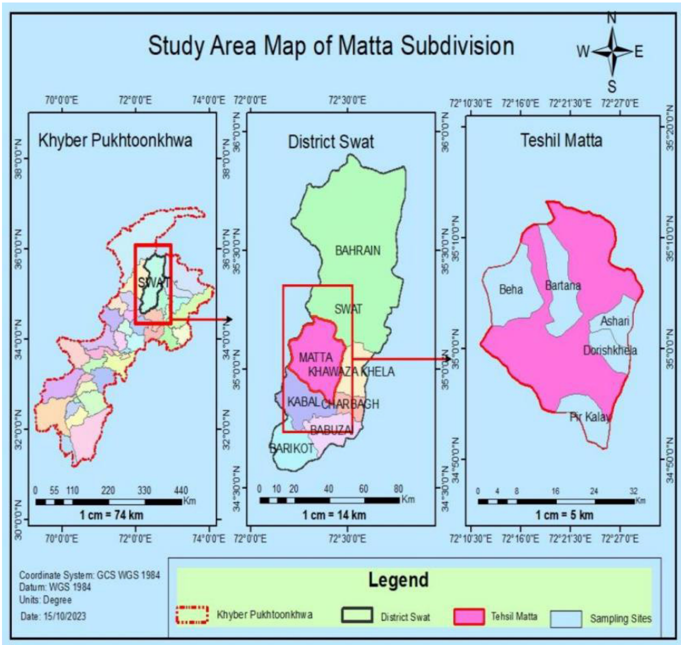

Figure 1: *Locations of the areas of sample plots in matta subdivision.*

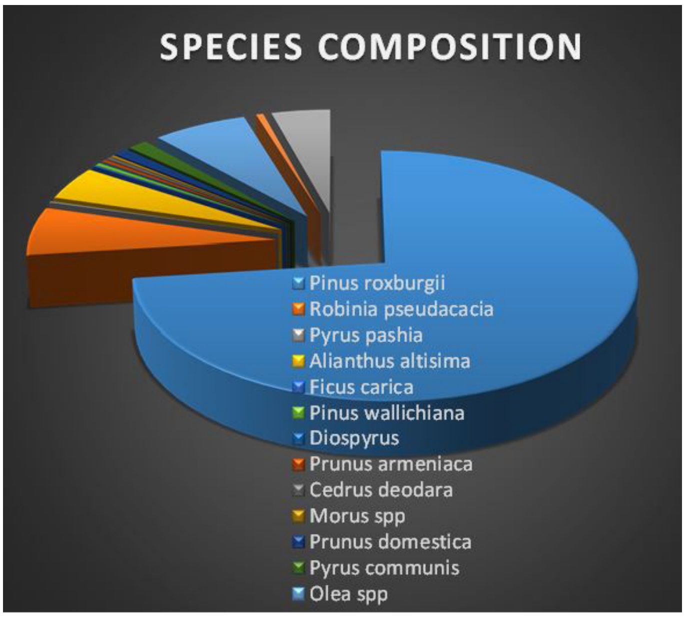

Figure 2: *Species composition.*

Electrical conductivity

The soil electrical conductivity of various sample plots was determined in our laboratory experiment. Plot No. 1 revealed the highest EC value, measuring 7.87, signifying the presence of highly conductive soil, likely attributed to mineral content enhancing electrical conductivity. In contrast, Plot No. 18 displayed the lowest EC value at 3.2, indicating soil with lower conductivity, possibly due to reduced mineral content or distinct soil characteristics. The dataset covered a range of EC values, both above and below the 3.2 to 7.87 range, showcasing diverse soil conditions. These observed variations in soil electrical conductivity have significant implications for agriculture, plant growth, and ecological considerations, as they directly impact nutrient and ion transport. These findings provides valuable insights for researchers and ecologists, enabling them to understand soil conditions, make informed land-use decisions, and implement suitable agricultural practices to optimize crop growth in different plots within a specific area.

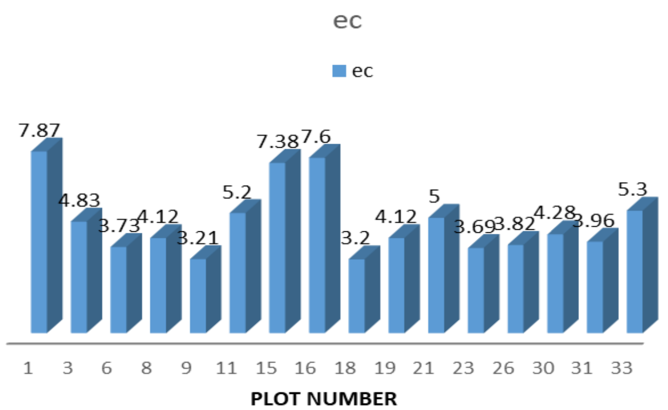

Figure 3: *Electrical conductivity.*

pH values

The graphic data display two variables: Plot number and pH (pH levels). Plot number denoted distinct areas or plots within a specific region, while the pH numbers corresponded to pH levels recorded at those, respective locations. The dataset covered plot numbers from 1 to 33, along with the corresponding pH values.

Upon closer examination, it became evident that the dataset exhibited a considerable degree of uniformity in pH levels, primarily centered around a pH value of 7. Most plots (1, 8, 9, 15, 21, 31, and 33) displayed a pH of 7.1, while others (3, 6, 11, 16, 18, 19, 23, 26, and 30) exhibited a pH of 7. This uniformity suggested that environmental conditions in this region maintained a stable state regarding soil acidity, with minimal fluctuations.

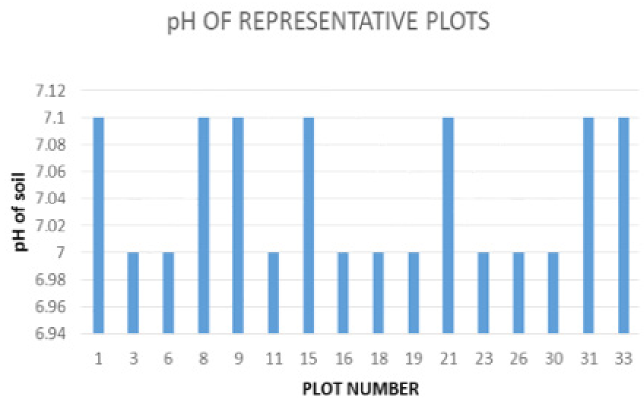

Figure 4: *pH of representative plots.*

The dataset held potential for long-term pH monitoring within these plots and served as a valuable resource for research related to soil quality and its impacts on ecological parameters such as plant growth, biodiversity, and other aspects within the specified area.

Moisture content

Moisture content of representative plots soil was determined as follows. The dataset shown in the illustration below is comprised of plot no and MC% (Moisture Content Percentage) values. These numbers represent the levels of moisture in the soil or material at each of the different particular plots. These results provide important new insights into the circumstances of moisture that exist within these locations. Plot no. 31 stands out as having a particularly high MC% of 15.0%, placing it towards the top end of the spectrum of moisture content. This suggests that the ground or other material at this place contains a substantial amount of moisture, which could be the result of water saturation or high groundwater levels. On the other hand, plot no 21 and plot no 26 had the lowest MC% values, coming in at 0.7% and 0.4%, respectively. These areas have soil or other materials that are excessively dry, which may be an indication of arid conditions or an absence of water content. The remaining plots have a moisture content that varies to varied degrees, ranging from 2.4% all the way up to 13.3%. The variety in moisture levels present across the plots has the potential to have substantial repercussions for a variety of applications, including ecological surveys, building projects, and agricultural endeavours. Certain types of crops can benefit from soils with a high moisture content, whereas soils with a low moisture content may require irrigation or influence decisions regarding land use. These data represent a significant resource that can be used to gain a knowledge of the moisture conditions present in these particular sites and to facilitate the making of decisions that are informed with regard to the land management and environmental concerns at hand.

Organic carbon %

The organic carbon content (O. carbon) of soil samples from different plots was determined. It's typically measured in percentage and involves plot no and OC (Organic Carbon) values, representing the organic carbon content in various plots. Organic carbon in soil is crucial for soil health, fertility, and ecosystem functioning.

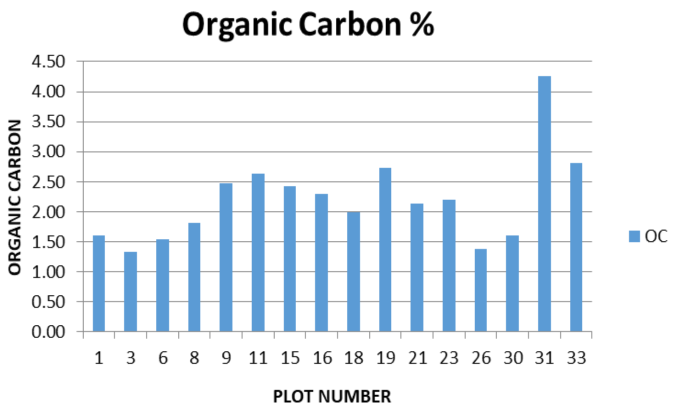

Figure 5: *Organic carbon.*

Observations: Plot no 31 had a significant OC value of 4.26%, indicating rich organic carbon content. This suggests the presence of substantial organic matter, likely from decaying plant and animal materials. Soils with higher organic carbon levels are generally more fertile, capable of retaining moisture, and providing essential nutrients for plant growth. Plot no. 31 appears to be a promising location for agriculture or other land use. Conversely, plot no 3 had the lowest organic carbon content at 1.34%, indicating less fertile soil less suitable for agriculture or sustaining healthy ecosystems. Low organic carbon soils often require amendments or management practices to enhance fertility.

The remaining plots in the dataset displayed organic carbon values ranging from 1.38% to 2.82%. These variations in organic carbon content indicate varying levels of soil fertility and ecological health within the analyzed area.

Siddiqui *et al.* (2009) studied relative density, frequency, and basal area of the forest floor, using circular plots in nine stands to record pine seedlings. Common angiospermic species with *Pinus roxburgii* included *Dodonaea viscosa, Punica granatum, Erodium cicutarium, Medicago denticulata, and Vicia sativa*. Rare species like *Ailanthus altissima, Daphne mucronata, Melia azedirach, Potentilla nepalensis, Urtica dioica,* and *Olea ferruginea* were observed. The studied forests showed signs of instability and degradation, indicating potential disappearance without proper maintenance. Our data provide a comprehensive view of the ecological composition within Matta Forest Subdivision in Swat Valley. *Pinus roxburgii* dominates at 73.0%, followed by *Robinia pseudacacia, Pyrus pashia, Alianthus altissima*, and *Eucalyptus camaldulensis* at 6.4%, 0.1%, 4.6%, and 4.3%, respectively. Other species like *Prunus domestica, Pyrus communis*, and *Olea* spp. contribute at 1.0%, 1.4%, and 6.9%, respectively.

In their study, Manan *et al.* (2020) identified 142 plant species from 62 families, clustering four plant associations within an altitudinal range of 1556–2313 m. They recommended designating *Parrotiopsis jacquemontiana* as an endangered species under specific IUCN red list categories. Their findings highlighted the significance of high phosphorus and potassium concentrations, elevation, aspect, slope, lower pH, electrical conductivity, and soil texture as environmental variables influencing vegetation structure and plant associations in the region. In contrast, our inventory documented 768 trees in sample plots, with *Pinus roxburgii* dominating at a frequency of 100. *Alianthus altissima* followed with a frequency of 28.57, and *Eucalyptus camaldulensis* had a frequency of 25.71, contributing significantly to the forest. Other notable species included *Olea* spp. (14.29), *Robinia pseudacacia* (22.86), and *Prunus domestica* (5.71), enriching forest biodiversity. Our study revealed the influence of soil pH, electrical conductivity, moisture content, and organic carbon on species dispersion, with average values of 7.04, 4.83 mS/cm, 6.11%, and 2.21%, respectively.

Conclusions and Recommendations

The study in Matta Forest subdivision of Swat reveals that *Pinus roxburgii* dominates the forest with 73.0% of total trees. Other significant species include *Robinia pseudacacia*, *Pyrus pashia*, *Alianthus altissima*, *Eucalyptus camaldulensis*, *Prunus domestica*, *Pyrus communis*, and *Olea* spp. The frequency values further highlight Pinus roxburgii's ecological dominance. Soil factors like pH, electrical conductivity, moisture content, and organic carbon also influence species distribution, with average values of 7.04, 4.83 mS/cm, 6.11%, and 2.21%, respectively. This data is valuable for assessing soil quality, informing land management decisions, and understanding the role of soil organic carbon in agriculture and ecosystem health. It provides crucial insights for researchers, ecologists, and land managers working to preserve and enhance the Chirpine forest ecosystem.

To conserve Matta subdivision forests, the following measures are recommended: Provision of alternative fuel/sources, prohibition forest construction, and promotion of ecotourism, Implement closure measures, prevent unauthorized deforestation, and regulate woodlot collection, Ban grazing, agricultural land conversion, and unapproved medicinal plant collection.

Novelty Statement

This study pioneers quantitative phytosociological analysis of Swat Valley's Chirpine forest, uncovering species diversity and soil factors driving ecosystem dynamics, and informing conservation strategies to protect this vulnerable ecosystem from land conversion and illicit harvesting.

Author's Contribution

BQ: Supervision. BA: Conceptualization. SH: Data curation, investigation. MAK: Writing original draft. SU: Writing review and editing.

Conflict of interest
The authors have declared no conflict of interest.

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