ECOLOGICAL KNOWLEDGE AND PERCEPTION OF CHANGES IN MORELS ABUNDANCE BY MUSHROOM (MORCHELLA) COLLECTORS IN NORTHERN AREAS OF PAKISTAN; A BIODIVERSITY HOTSPOT

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Abstract

The present study was carried out during the months of April to August in the years of 2020-2022. The study aims to identify and collect Morchella species along with its associated vegetation from the study area district Swat. Morels (Morchella spp.) are highly valued wild edible mushrooms. In Swat district Khyber Pakhtunkhwa, Pakistan, morels are the focus of the poor family traditions, along with valuable commercialized trading. Morchellasamples were collected using quadrat quantitative ecological techniques, with soil samples analyzed for physicochemical parameters using standard laboratory methods. During this study we collected and identify a total of 4 species of Morchella (Morchella esculenta, Morchella elata, Morchella conica and Morchella semilibera) were along with 76 plant species recorded from the study area. Floristically, these plant species belong to 40 different families. Among these, plant species 15 (20%) were trees species, 9 (12%) were shrubs species, while 52 (68%) were herbs considered as a habitat. Data analysis utilized PC-ORD and CANOCO Software for ecological assessment.Our results indicate that soil sand, clay content, pH, and moisture showed positive associations with species abundance. Our study provides insights into a diverse ecology and conservation. This research presents that focused on morel hunters, habitats, associated vegetation, local ecological knowledge of morel types, and responses to various disturbances. We concluded that expert morel harvesters have some local ecological information that can help us better to understand scientific knowledge of Morchella. This local understanding of the regionally complex ecology of Morels may help in inform conservation management.

Keywords: *Fungi, Morchella, Fungal ecology, Local ecological knowledge, Multivariate Analysis, Swat Valley*

Introduction

Fungi are diversified group of organisms that have evolved in every environmental niche. Around 1.5 million species of fungihave been documented from the world throughout, however only 70,000 have been recognized so far (Hawksworth, 1995). The abundance and character of the soil's organic content, as well as other soil and climatic factors, surface vegetation, and soil texture, all influence the dispersion of fungi. The variety of soil micro fungi has a big impact on ecosystem balance and production. In Pakistan, around 700 species of Basidiomycota have been documented (Sultana et al., 2011). Fungi, particularly microscopic ones, have few important morphological traits and exhibit a great deal of morphological variety (Burnett, 2003). Fungi have a surprising amount of genetic diversity (Taylor et al., 2000).

Morels belongs to the Helveliaceae family and class Ascomycetes. Morels flourished all-round the northern hemisphere, subtropical and Mediterranean zone (Pilz et al., 2007). Morels are categorizing as ascomycetes i.e., fungi which making spores in ascus. The morels (Morchella) are classified into three Broad categories, such as yellow morels, black morels and half morels.Morels can be saprobes, feeding on dead food to extract nutrients, or extracting nutrients through symbiotic relationships with photosynthetic plants. *Morchella conica* and *Morchella rotundus* appear to be associated with some other tree species, with *Morchella conica* being found mostly on conifers and *Morchella rotundus* on smaller trees. Morels are very cold tolerant and we've seen fruit in temperatures up to 42 degrees. Ecology is specific to different areas and countries.Upon suitable moisture conditions and temperature, morels possess three kinds of fruiting ornamentation (Wurtz et al.,2005). Morels can be saprophytic or ectomycorrhizal. They make relationships with evergreen and deciduous tree species.

One of the most significant aspects of biological diversity is ecological diversity (CBD, 1995). Biodiversity refers to the diversity and heterogeneity of creatures or features found perfectly in all steps of the biological hierarchy. Species diversity is usually the emphasis, however more types of variety i.e., chemical and genetic diversity, as well as significant and instructive (Purvis and Hector, 2000). The richness or taxonomy, evenness, and variety of creatures, together with genetic variation in species and ecosystems, contribute to biodiversity (Burely, 2002). Apart from the economic, ethical, and aesthetic benefits, biodiversity is critical for ecosystem functioning and stability (Schulze and Mooney, 2012). Mountains are important ecosystems with a unique physiography and a wide range of species (Khan, 2012). They contain a quarter of the world's biological diversity, half of the world's hotspots, and a large number of ethnic groups with diverse cultures (Spehn et al., 2012). The role of species diversity in understanding the position, ecological pattern, and changeability of biodiversity has been demonstrated (Sorrie et al., 2006).

Traditional ecological knowledge informs users about community and habitat change. The information can be used to build scientific consensus (Huntington,2000), support environmental management (Moller et al., 2004) and develop and implement conservation measures (Mollnar et al., 2016).Morels are the world's most commonly consumed mushroom species and are being introduced to rural populations in Swat Valley, Pakistan.Environmental factors such as soil type, vegetation, temperature, pH, relative humidity and moisture and organic matter in the substrate limit fungal life and spread, space and time (Weberet al.,1988). Moisture availability is one of the most important factors in the production of mushrooms. Elevation and aspect are the most important elements impacting morel distribution in hilly or mountainous environments (Pilz et al., 2007). Other ecological elements that influence mushroom development, such as topographic features, rainfall, humidity, and plant-mould relationships for morel fruiting, have been studied by many researchers. According to (Manikandan et al., 2011) the best substrate for morels, is loamy, dark, fertile and rich organic matter soil. Traditional and local ecological knowledge also helps to develop new scientific questions and testable hypotheses (Gantuya et al., 2019). Traditional ecological information, such as habitat categorization and landscape partitioning linked to ecosystem types and habitat (Nakashima, 2018). Folklore environment descriptions and land partitionings have recently demonstrated the complexity and intricate characteristics of folk habitat types. Folk habitats may be divided into three categories i.e., meso, macro and micro-scale habitats. Macro habitats cover a large area and include a variety of habitat types, creating a mosaic. Meso environments are often shorter, homogeneous, and controlled by a single kind of plant. Microhabitats are microhabitats that are implanted in meso habitats and give unique niches for certain species (Nakashima, 2018).

Local communities have evolved their own perceptions of environmental changes as a result of interacting with and influencing their environment, which are produced not just by natural but also by human processes (Gadgil et al., 2000). Local observations of environmental change have recently gained by scientific recognition (Volpato et al., 2013). Studying local knowledge, according to (Palucki et al., 1973), may help us better understand the trends in continuing ecological changes. Local ecological knowledge data may be particularly useful in managing complex societal and ecological organization adaptability, independent of change and revelation (Berkes et al., 2000).Comparative analysis of multiple interviews provides valuable information on audience interaction (Lampman, 2005). Information obtained from local ecological knowledge reduces the general category of spatial arrangement of scientific environmental knowledge (Roth,2004). The aim of the current research in fungal ethno ecology is: 1) To explain the locals' perception of Morels ecology 2) To explain the locals' perception of Morels abundance 3) A large number of mushroom collectors were observed to document habitat preferences as well as other aspects 4) Finally, based on the foregoing data, generate a hypothesis for further Morels research.

Materials and Methods

The present study was carried out in the valleys of Swat district 9Madyan, Malam Jabba, and Kalam) during the months of March 2020 to July in the year of

2022. The research areas were visited to collect local ecological knowledge about morels species. The study's main focus is on local ecological knowledge and morel trends. Knowledge about morels was collected from local purchasers, local collectors and exporters.

Study area

Morels samples were collected from different areas in the province of Pakistan Khyber Pakhtunkhwa's Swat District during the year of 2020-2022. Swat valley is located between 34°-40′ and 35° N latitude and 72°-6′ and 74°-6′ E longitude (Figure 1). The famous Hindukush mountain range's foothills surrounds it in the Khyber Pakhtunkhwa, the north west province of Pakistan. Total area of the district is 5337 km^2. Great variation in topography, altitude, climatic and biotic condition in the area supports diverse form of plants and mushrooms species.

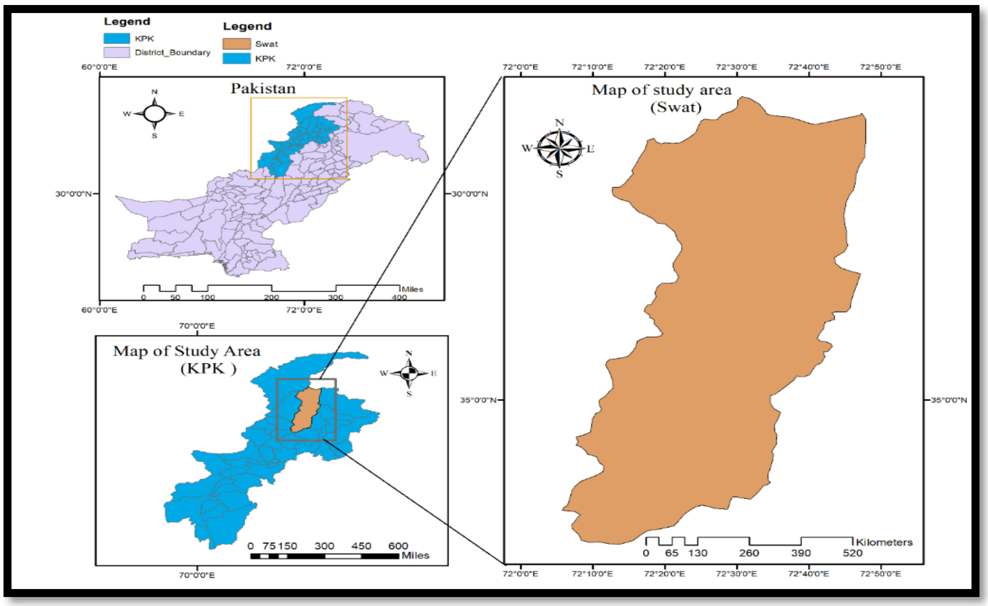

Figure 1.Map showing the study area used for exploration of fungal species (Mushrooms).

Collection of (Morels) mushrooms

Mushroom samples were collected in the rainy seasons of October to November and summer (May to June) during the years of 2020–2022 in Pakistan's District Swat, Khyber Pakhtunkhawa, Pakistan. Major macro-morphological characteristics of the fresh samples, including the time of collection, the season, the type of soil, the kind of flora, the habitat, etc., were noted in field notes throughout the study. Mushrooms were gathered, photographed in their natural environment from all angles, including the pileus, gills, and stipe, and stored in card boxes. Each specimen had a collection number, a date, and the name of the location attached. Different species have adopted distinct fruiting structures that vary from locality to locality and season to season. Using a sharp digger, fruiting bodies of mushrooms were gathered (Samina, 2013).

While the mushrooms that were present on their natural environment or substrate were also gathered. The images were captured in their natural environment.

Sampling of vegetation

Quadrat quantitative methods were used for the collection of ecological data. A total of 20 quadrats were done in the study area. The size of the quadrat was, $1\times1m^2$, $5\times5m^2$ and $10\times10m^2$ for shrubs, herbs and trees, respectively (Khan et al., 2013). The specimens of Morchella and other associated plant species were also collected during field surveys. The nearest trees, shrubs, and herbs data were also recorded. The whole research area was visited on a regular basis in order to identify native plants species and collect data on floristic diversity. The nearest trees, bushes, and herbs were measured independently from the plot center to determine related plant distance (by considering Morchella as plot center).

Soil collection

For the investigation of several chemical and physical parameters, such as TDS, EC, pH, organic matter, Moisture content, soil samples were taken from various areas of District Swat, Khyber Pakhtunkhawa, Pakistan. The topsoil samples were gathered from selected quadrates up to 15cm depth. We were collected 200 to 300 grams from each quadrate. Before collection organic matter and humus were removed. The samples were collected using clean plastic bags. A permanent marker code was used to identify the soil that had been gathered and sealed in plastic bags. Samples of soil were cleared of stones, plant roots, and other debris before being dried in the shade. For additional examination, the soil samples were sent to the Plant Ecology and Conservation Laboratory of the Department of Plant Science at Quaid-i-Azam University in Islamabad.

Field visits

The field visit included observations, semi-structured interviews, open-ended, field interpretations, and data collecting via questionnaires. Observations were made on a field trip to the study areas (Kalam) to examine the native species. Questionnaire method was adopted for this purpose according to (Wojewoda, 2003). The data obtained from the questionnaire was cross checked with available literature. The data was collected by asking informants a series of questions such as, where did you get this mushroom species information. Questions about fungal habitat and abundance changes were asked to all 360 respondents. Pre-designed questionnaires along some modifications were used to collect floristic data both directly and indirectly. During field interviews, the great majority of upcoming identifying samples were obtained from new respondents, whereas others were obtained dry.360 people responded by providing knowledge on fungal ecology. Women accounted for 30 percent, while males accounted up to 70 percent and children up to 60 percent from people who used a variety of methods to collect information about morels. The informants were ranged in age from 15 to 67 years old.The findings presented here based on our interactions with 360 people. Data on gender, age, and educational attainment were gathered.

Drying, preservation and Identification of morels

Morel harvesting is traditionally done by local people, and there is no drying technology. So the Local people used its own methods for drying. The drying process is carried out by the collector using a needle and thread, and the morel flowers are hung on the wall of the house or on the rafters. And drying depends on the time, but it usually takes 4-5 days.The collected specimens were carried to the laboratory. With the help of the existing literature and using the characteristics of mature morels species, the characters were recorded for identification and up to species level (Kishwar et al., 2007). With the help of the Flora of Pakistan, an expert taxonomist, and other literature that was available, related plant species were identified.

Data Analysis

Data were entered and processed using Microsoft Excel (QSR International 2006) for analysis. The PCA principal component analysis was carried out. The first principal components used to determine which direction increases projected point variation, allowing some fungal species to be divided into groups with comparable environmental preferences. The min-max scaling approach was used to normalize the data, as well as singular value decomposition (SVD). The FactoMine R module in Rstudio software was used to do PCA analysis in the R programming language. During the mushroom collecting period, we counted the number of people who noted a shift in general macro fungal abundance. Information were gathered on observed changes in the quantity of certain fungus in some situations. The data collected was utilized to produce morels abundance dynamics maps, which documented the primary reasons of the changes. Environmental data were analyzed through multivariate statistical software. The effect of several measurable ecological conditions on the distribution of mushroom with related plant species has been examined using multivariate statistical methods (Digby et al., 2012). In this study morels samples and 76 plant species were analyzed for various environmental variables at 20 different stations. In order to classify associated plant species into different associations, all the data environmental variables and on plant species were entered into Microsoft Excel 2010 and produced the data 0,1 for the CA and TWCA of PCORD version 5 (Lepš and Šmilauer, 2003). Canonical correspondence analysis and Detrended correspondence analysis were carried out using CANOCO software version 4.5 to conduct ordination analysis in order to determine the effects of various environmental variables on the composition, distribution, and abundance of associated plant species (Anwar et al., 2019). Aspects, altitude, organic content, pH, and other environmental variables were treated.

Results

Morels are collected from study areas (Kalam Malam Jabba and Madyan) during the months of April to August. Locally they are called Kasee or Gujai (Table 1). In the present study, we collected and identified a total of 4 morels species *Morchella conica*, *Morchella esculenta*, *Morchella semilibera* and *Morchella elata* species along with 76 associated plants species recorded from the study areas. The collectors sold it to local shopkeepers or in the markets of Madyan and Mingora. Morchella fetch high prices and thus play an important role in the economy of Swabi Valley.Floristically, these species belong to 40 different families.

Table 1 Diversity of Morels (Morchella) Species Recorded from the Study Areas

S.NO	SCIENTIFIC NAME	FAMILY NAME	SUBSTRATE	LOCALITY	EDIBILITY STATUS
1	*Morchella elata*	Morchellaceae	On grass	Swat	Edible
2	*Morchella esculenta*	Morchellaceae	On grass	Madyan	Edible
3	*Morchella conica*	Morchellaceae	On grass	Kalam	Edible
4	*Morchella semilibera*	Morchellaceae	On grass	Malam Jabba	Edible

Among these, plant species 15 (20%) were trees species, 9 (12%) were shrubs species, while 52 (68%) were herbs considered as a habitat shown in (Figure 2).

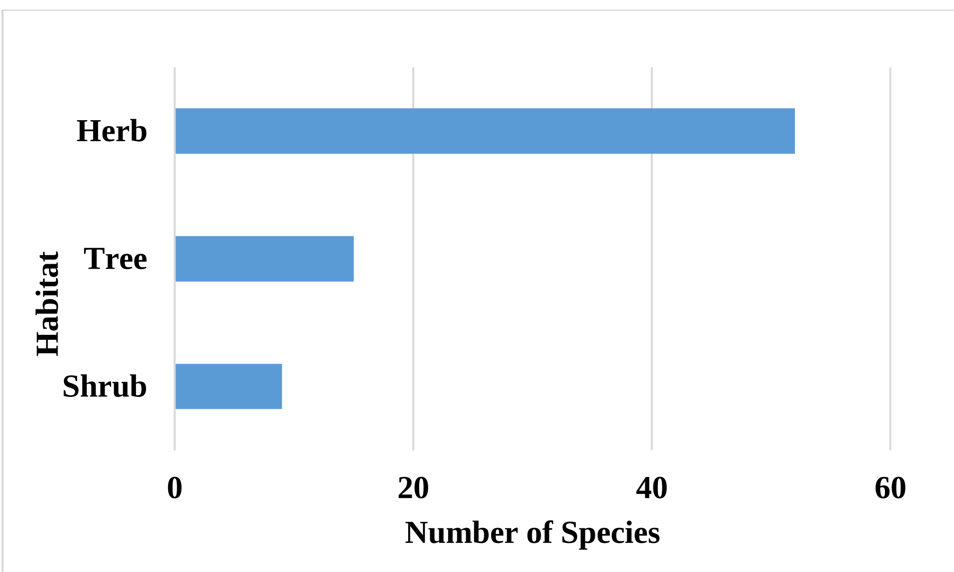

Figure 2. Habit wise distribution of plants species.

Family wise composition

In the present study the top most dominant family is Rosaceae having 7 species followed by family Fabaceae having 6 species, While the second dominant families are family Caryophyllaceae, Asteraceae and Pinaceae having 5 species, although Oleaceae, Sapindaceae, Urticaceae, Amaranthaceae, Berberidaceae, Lamiaceae, Plantaginaceae and Polygonaceae families having 2 species each, while Viburnaceae, Amaryllidaceae, Primulaceae and Pteridaceae families having only 1 species (Table 3).

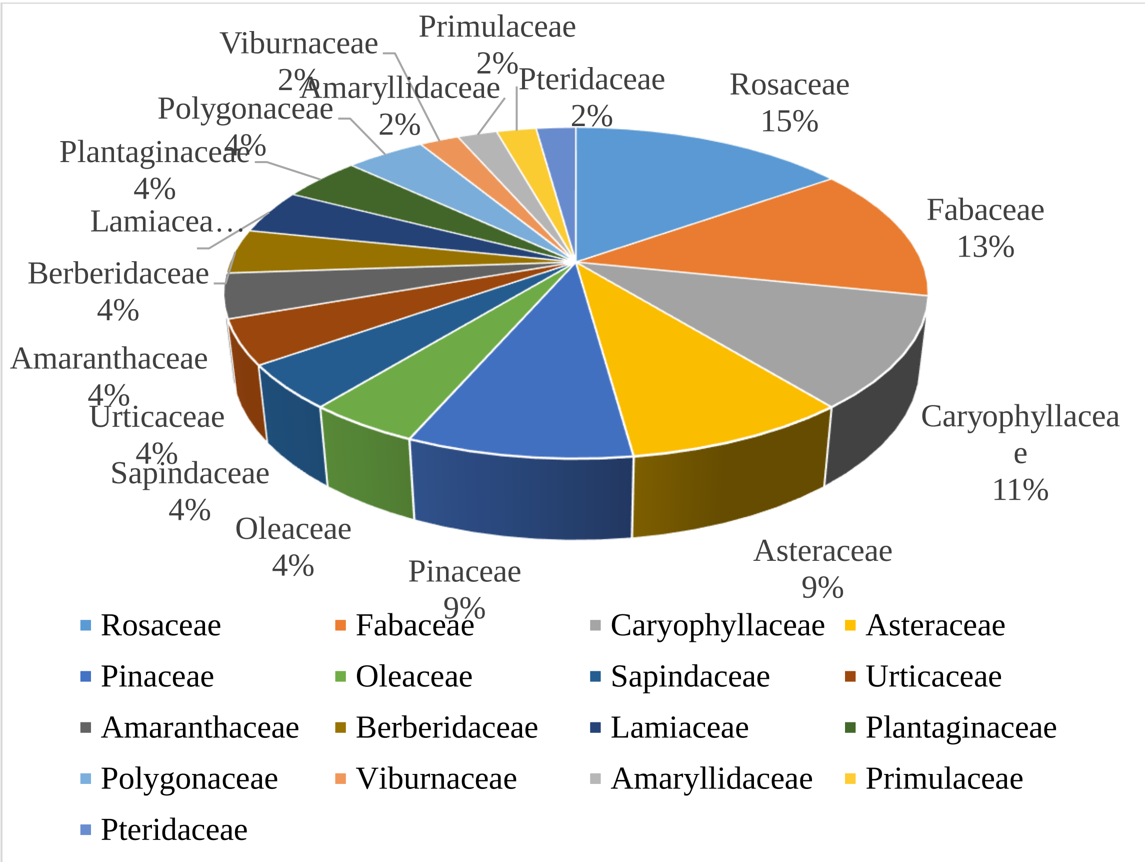

Figure 3. Family wise percentage distribution of Plant families.

Morels Abundance

Our present result indicated that Morels abundance is fluctuated along with various factors as perceived by locals. These factors include disturbance, temperature, canopy, aspect, slope, soil texture, habitat and distance from roads etc. (Figure 4).

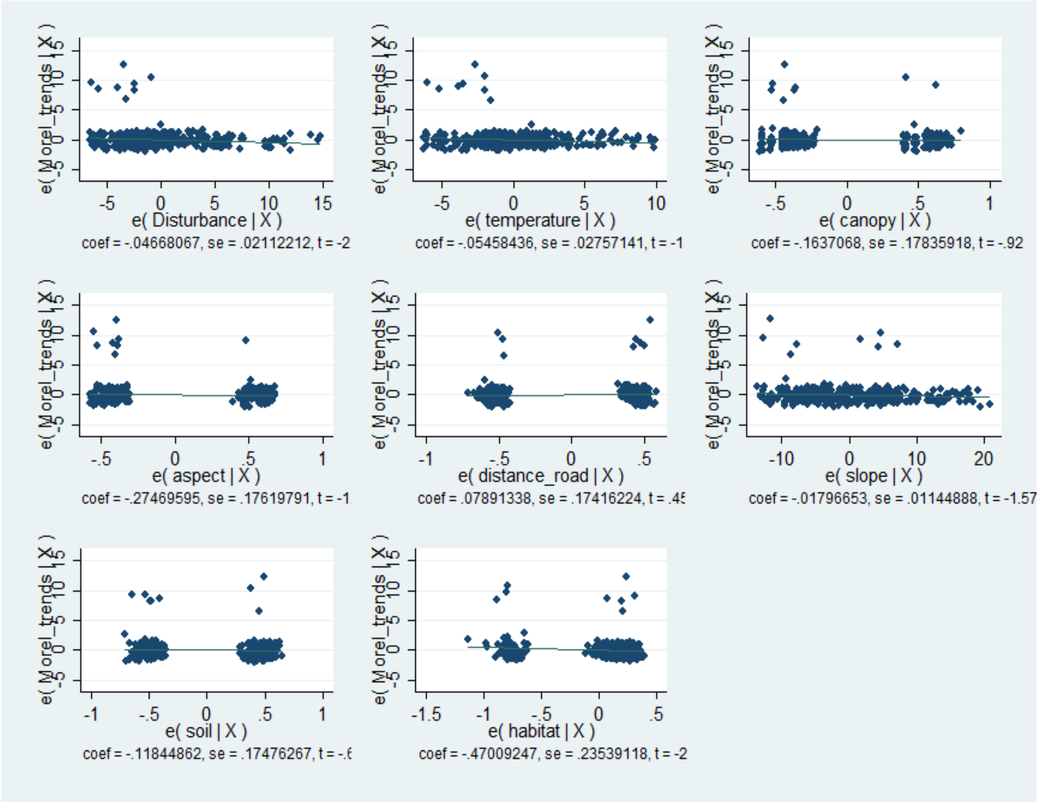

Figure 4. Coefficient of correlation of Morels trends with factors.

Our present result indicated that Morels abundance is greatly influenced by disturbance factor (Figure 5). Disturbance includes deforestation and non-sustainable harvesting of Morels. Rapid urbanization and construction in the natural forested lands also contributed towards decrease in Morels abundance. Extreme dry conditions and rapid climate changes also contributed to decrease in Morels population. Among the 360 indigenous respondents, 285 (79%) reported high disturbance in the morels habitat whereas 56 (15.5%) participants reported less disturbance.

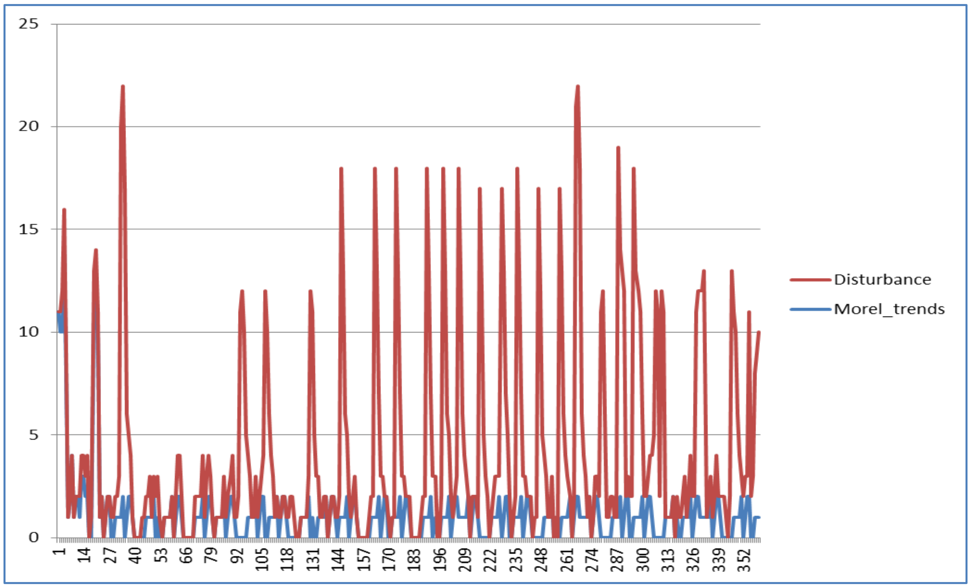

Figure 5. Disturbance and Morel trends.

Specifically, temperature rise and fall also impacted the Morels population (Figure 6). Among the local respondents 82% described low temperature as best for morels growth. Moderate temperature is reported by only 8% (29) locals while a few i.e. 2% (10) reported that some species of morels grow best in high temperature (Table 2). Dry conditions and low rainfall decreased the Morels in the study area.

Table 2. Temperature fluctuations and morels trends.

Temperature status	Respondents	%age
Low temperature	298	82%
Moderate temperature	29	8%
High temperature	10	2%

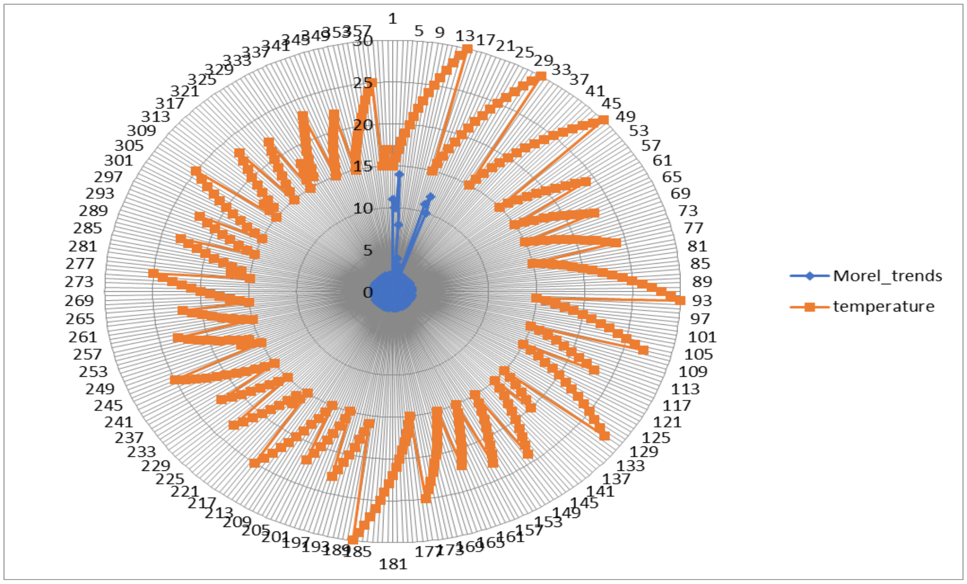

Figure 6. High temperature decrease Morel population.

Morels abundance is also influenced by slope factor (Figure 7). Morels are mostly reported in plain forested areas as perceived by 256 (71%) respondents (Table 3). Decrease in Morels abundance in steep slope areas and almost absent in sharp slopes. So slope also contributed towards Morels population dynamics.

Table 3. Slope variations and morels trends.

Slope variation	Respondents	%age
Plain	256	71%
Low slope	67	19%
High slope	37	10%

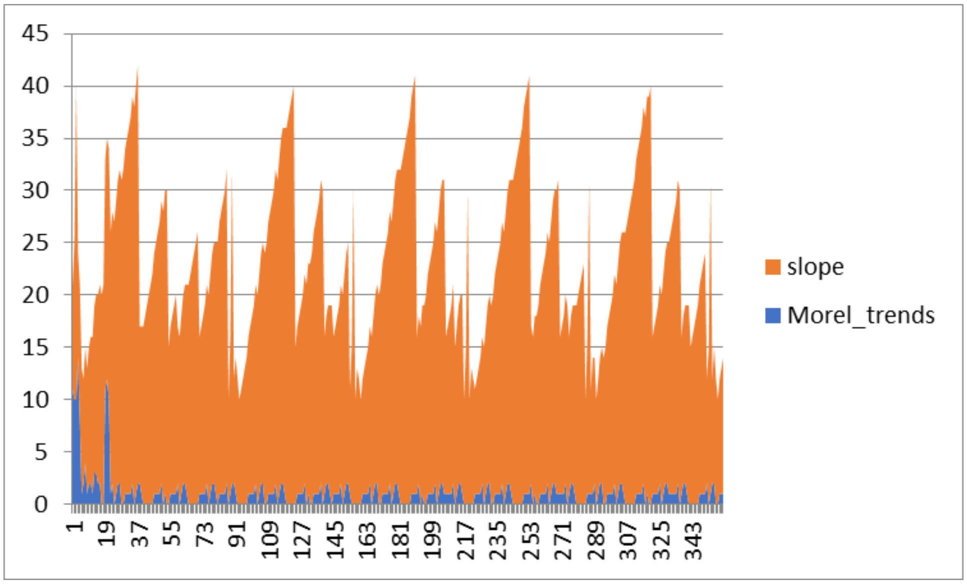

Figure 7. Slope and Morel trends.

Mostly species reported in wet and conserved habitat with least disturbance. Extreme dry conditions and rapid climate changes also contributed to decrease in Morels population. Changing disturbance regimes are likely to be a factor in actual or perceived morel reductions. Yellowish mushrooms, in certain, might possess dropped as a result of the elm population crash, which caused an increase in fruiting. Some wildlife species' populations are also expanding, according to the participants.

Multivariate statistical analysis

Cluster analysis

The cluster analysis was performed using PCORD version 5. It classified all the 20 quadrates and 76 Plant Species into four associations/ groups based on Sorenson Distance Measurements (Figure 8).

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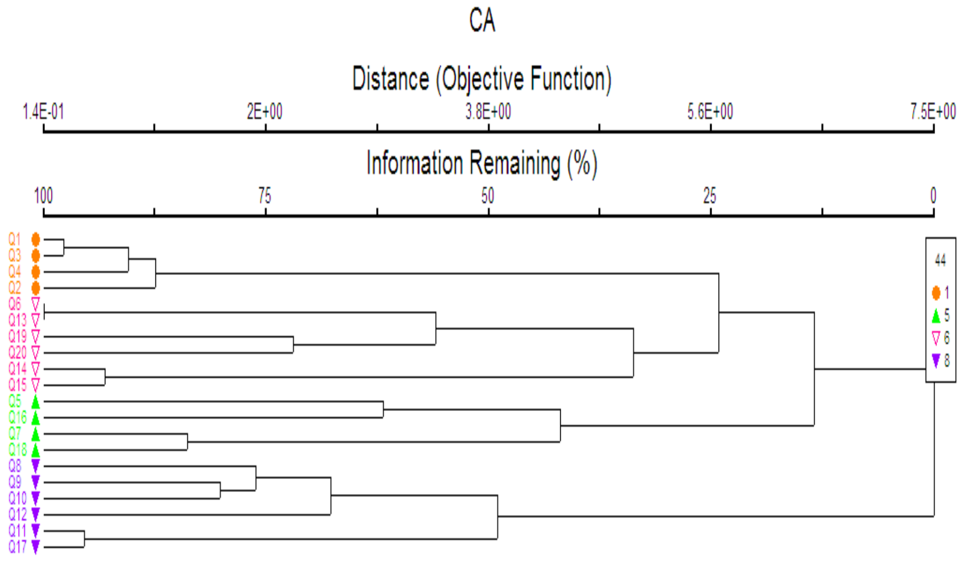

Figure 8. Cluster dendrogram of 20 quadrats showing 4 plant communities based on Sorensen distance measurement.

Two Way Cluster Analysis

Two-way Cluster Analysis was employed to illustrate the number of quadrats and the distribution of plant species (TWCA). The black dots in the two-way cluster denote the existence of species, whereas the white dot indicates their absence (Figure 9).

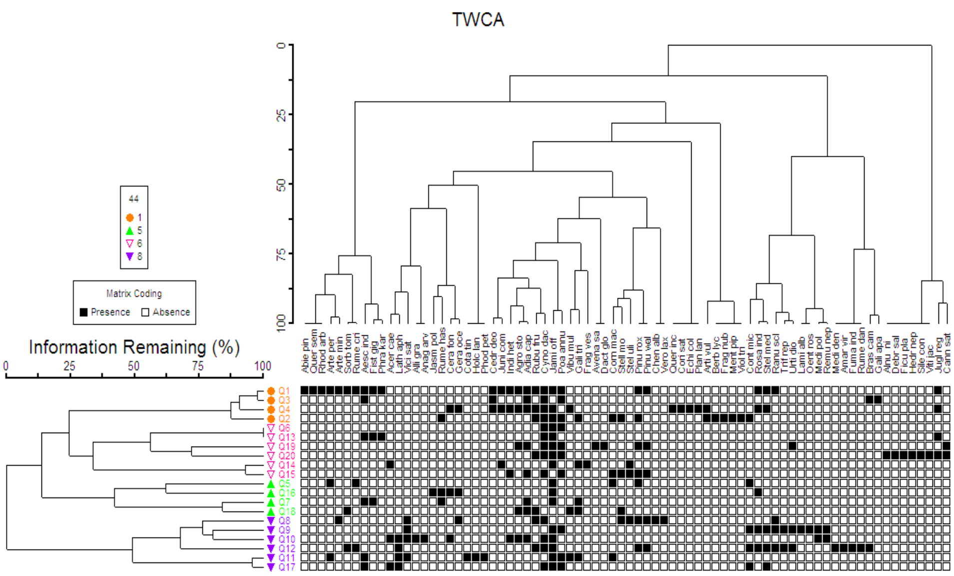

Figure 9. Using PC-ORD version 5, a two-way cluster analysis dendrogram of Plant species and 20 quadrats was created using Sorensen measures that indicate groups of plant species and quadrats.

Canonical correspondence analysis for environmental variables and Plant species

This CCA bi-plot consisted of key factors of morels along relationship with various gradients was shown in (Figure 10). The first quadrant showed that most of the plant species were under the effect of canopy and regeneration. Similarly, the second quadrant was affected by the gradients like soil texture (silt and clay), PH, Electrical conductivity and Organic matter. Whereas moving to the third quadrant most of the associated species of morels were affected by grazing pressure. The fourth quadrant was influenced by gradients corresponding to sand, anthropogenic pressure and elevation.

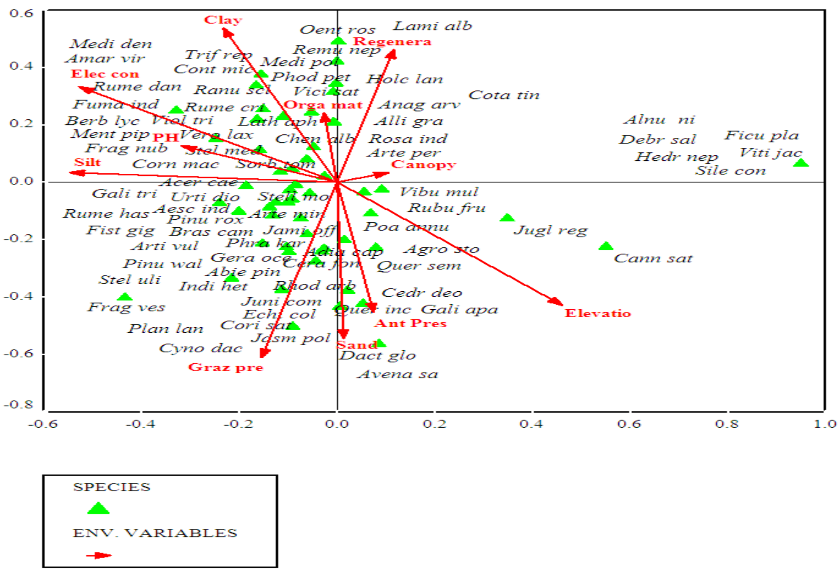

Figure 10. CCA data attribute plot showing correlation between environmental variables and its associated plants species.

Canonical correspondence analysis for morels species and environmental factors

This CCA bi-plot consisted of associated plant species of morels whose relationship with various gradients was shown in (Figure 11). The first quadrant showed that most of the plant species (*Alnus nitida*, *Rosa indica*, *Hedra nepalensis*,) were associated/ grouped around *Morchella elata*. Similarly, in the second quadrant the associated vegetation of *Morchella conica* includes; (*Amaranthus viridis*, *Trifolium repenes*, *Fragaria nubicula*,). Whereas moving to the third quadrant most of the associated species (*Pinus wallichiana*, *Vicia sativa*, *Medicago denticulate*,) were grouped *Morchella esculenta* around this morel. The fourth quadrant associated vegetation (*Viola tricolor*, *Galium apairne*, *Poa annua*,) of *Morchella semilibera* includes.

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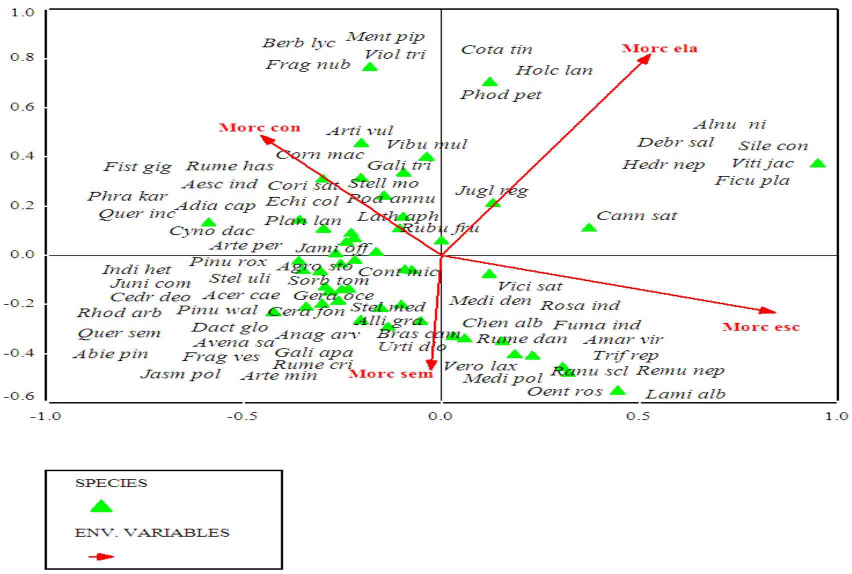

Figure 11. CCA biplot showing relationship between Morels species and environmental variables.

Discussion

Regarding available mushrooms and their possible use, Swat is still unexplored. Consequently, a survey was carried out in various locations during various seasons (2020-2022). In this study we used quadrate quantitative ecological methods for the sampling of vegetation. Morels are collected from study areas (Kalam) during the months of March to July. Locally they are called Kasee or Gujai. In the present study, we collected and identified a total of 4 morels species *Morchella conica*, *Morchella esculenta*, *Morchella semilibera* and *Morchella elata* species along with 76 associated plants species recorded from the study areas. Floristically, these species belong to 40 different families. Among these, plant species 15 (20%) were trees species, 9 (12%) were shrubs species, while 52 (68%) were herbs considered as a habitat. In the present study the top most dominant family is Rosaceae having 7 species followed by family Fabaceae having 6 species, While the second dominant families are family Caryophyllaceae, Asteraceae and Pinaceae having 5 species. Comparably, the quantitative quadrat ecological technique was also used by (Habib, Badshah, Ahmad & Khan 2023) in the vegetation sampling for their individual investigations. Our findings correspond closely with those of numerous other studies conducted in related fields. In the adjacent Gadoon rangeland in District Swabi, Pakistan, 260 plants species were reported by Sher et al., (2014), comprising 211 taxa and (90) families (Zaman Sher, Hussain & Badshah 2014). In total, 211 species of vascular plants from 170 genera and 66 families were identified by Fazal et al., (2010) from the nearby District Haripur in the Hazara Division (Fazal, Ahmad, Rashid & Farooq 2010).

Plant species were categorized into probable plant communities and associations utilizing PC-ORD version 5. The cluster analysis was performed using PCORD version 5 in this study. Using Sorensen distance measures, it categorized all 20 quadrats and 76 species into four distinct communities. Two-way Cluster Analysis (TWCA) was used to display the number of quadrats and the distribution of plant species. In the two-way cluster, the black dots show the presence of species, and the white dot shows their absence. On ecological data, ordination methods like CCA and DCA were carried out using version 4.5 CANOCO software. Detrended and Conical Correspondence Analysis are essential tools for determining how one plant species and its distribution relate to several environmental factors. We compared every plant species with the soil data using the CANOCO programme. The variety, distribution, and abundance of plant species were significantly 84 influenced by all environmental conditions, often known as edaphic factors.

This CCA bi-plot consisted of key factors of morels along relationship with various gradients was shown. The first quadrant showed that most of the plant species were under the effect of canopy and regeneration. Similarly, the second quadrant was affected by the gradients like soil texture (silt and clay), PH, Electrical conductivity and Organic matter. Whereas moving to the third quadrant most of the associated species of morels were affected by grazing pressure. The fourth quadrant was influenced by gradients corresponding to sand, anthropogenic pressure and elevation. Hu et al., (2022) state that the morels CCA revealed the most important environmental parameters. influencing the existence and dispersion of morels. The impacts of environmental conditions on the species richness of distribution and diversity of morels species were independently investigated using the PCORD Software. Our findings in each vegetative zone are consistent with those of other researchers (Haq et al., 2015a; Ilyas et al., 2012). This CCA bi-plot consisted of associated plant species of morels whose relationship with various gradients was shown in (figure 2). The first quadrant showed that most of the plant species (*Alnus nitida, Rosa indica*, *Hedra nepalensis,*) were associated/ grouped around *Morchella elata*. Similarly, in the second quadrant the associated vegetation of *Morchella conica* includes; (*Amaranthus viridis, Trifolium repenes, Fragaria nubicula,*). Whereas moving to the third quadrant most of the associated species (*Pinus wallichiana, Vicia sativa, Medicago denticulate,*) were grouped *Morchella esculenta* around this morel. The fourth quadrant associated vegetation (*Viola tricolor, Galium apairne, Poa annua,*) of *Morchella semilibera* includes.

The present work was about the local ecological knowledge of mushroom collectors in northern areas of Pakistan's and observation of change in morel abundance along with its associated ecological data. Habitat degradation on large scale, pollution and change in climate are all identified by mycologists as major dangers to fungus in general (Egli et al. 2006). Our present result indicated that Morels abundance is fluctuated along with various factors as perceived by locals. These factors include disturbance, temperature, canopy, aspect, slope, soil texture, habitat and distance from roads etc. In the Western Himalayan region of Swat, Kanwal et al., (2011) discovered five morel species. Based on these past researches we started to assess local ecological knowledge and morels abundance in swat.

In the Swat region, Hamayun et al., (2006) found seven species.Richard et al., (2015) described 21 European species. There are no previous reports on morel ecological knowledge and local perception in our project region (Kalam, Malam jabba and Madyan). FGD is mostly used to evaluate organizational interventions or previously accessible solutions (Mukherjeeet al., 2018). FGD is efficient in allowing information flow to move slowly, which assists in disclosing evidences and views of persons and can help in acquiring various evidences concerning morel purchasing. Prices have gradually increased. Per kilogram costs in (Swat) Kalam varied from US$ 7 to US$ 40, according to Kakakhel (2015). Morel rates vary (US$ 30-50) in different market places (Hamayun et al., 2006). This refers to a recent increase in morel market rates in Pakistan's various markets. Non sustainable harvesting of Morchella species were declined as perceived by local people. The current study serves as a baseline for predicting the future trends of morel conservation and sustainability in the valley. Dark, rich, loamy, black and fertile soil is regarded as ideal for morels. Black soils are more commonly found at higher elevations than white and yellow. Morels are commonly found in lush forests, flood plains as well as in association with wood chips in the mid-west. Our results indicated that Morchella species grow best in clay, loamy and silty soils.

According to Weber (1988), morels are associated with ash, tulip, elm, as well as forest types, trees and fruits. Morels tend to be more closely associated with oak and white pine in the Midwest than in the Mid Atlantic. Our results showed that these mushrooms grow best in close canopy or under the shade of tall vegetation, which confirmed the importance of associated vegetation. Disturbance has both beneficial and negative impacts on morel fruiting. Morel fruiting has been shown to be harmed by heavy logging or blow downs, especially if tree companions are harmed. Morel fruiting is affected by disturbance in both positive and negative ways. Morels’ fruiting has been shown to be affected by high rate of deforestation. Morel fruiting appear to be impacted by flooding. Our results indicated that the most disturbed areas lack the presence of mushrooms while a lot of species observed in least disturbed or area which was conserved.

According to Weber et al., (1996), soil habitual disruption enhances the richness of *M. esculenta* and *M. semilibera*. Morel abundance bursts have been connected to tree mortality due to insect or disease in the Pacific Northwest and Midwest (Kuo, 2005). Several experienced mushroom hunters believe that in recent years there has been a general tendency toward an earlier season start, maybe by two weeks. The climatic conditions needed for morel fruiting are described by Pilz et al., (2007). Low morel hunting triumph in the research area is almost probably due to habitat loss, and development is a key concern for participants. Many participants were thought the fungicide use to control the moth infestations killed the morel species, but Weber (1988) state that morels don't produce fruit in fungicide-treated orchards. Bacillus thuringiensis was sprayed on a national park in our research region in 2008. If there is a relationship between usage and decreased morel fruiting, Pilz (personal communication) postulates that it might be related to host tree advantages.

Conclusion

Our study clearly determined that morels abundance is higher in particular ecological condition such as low temperature, disturbance, Soil organic matter, and slope level. The data collected on Morel's ecology demonstrated that local knowledge typically does not differ from knowledge of science. Morel abundance and ecology data may also be utilized to develop new scientific inquiries and ideas. This study will further help in the understanding of Ethno-ecological knowledge, and natural environment in order to provide a baseline for future Morel conservation and management planning in the natural forested areas. Comprehensive sampling is also required in the area for the preservation of habitat integrity and scientific management of Morels' in natural habitat. As compared to ecological data the current study's findings resulted that district Swat wintertime environmental conditions were more suitable for the growth of morels production. Additionally, the results of the study provided more evidence that morels growth were significantly higher in the District Swat plains areas under ecological conditions. The District Swat is a diverse habitat and also supports a remarkable phyto-diversity, shown by the 76 plant species that have been identified. All plant species were divided into five groups using the PCORD version 5 programme. The indicators for pH, Canopy, altitude and Slope are shown. Strong correlations are also found between Morels species, plant species and abiotic variables, according to analyses using canonical and Detrended correspondences.

Author contribution

HG, NB, FH, FA and HA conceptualized the research, IA, BC, conducted analysis, AR Supervised the manuscript, HG, KI, NB, FM, DKB and FA wrote the original manuscript. The authors approved the current version for publication.

Conflict of interest

The authors declared that there is no conflict of interest.

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