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SPECIES DIVERSITY AND ECOLOGICAL ANALYSIS OF MACRO-FUNGI OF DISTRICT SWABI, KHYBER PAKHTUNKHWA, PAKISTAN

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Abstract

This research presents an analytical investigation of Macro-fungi found in district Swabi, Khyber Pakhtunkhwa, Pakistan. The aim of the study was to examine species diversity and community structure of Macro-fungi in relation to climatic, topographical and edaphic factors. A year-long survey was conducted in 2022-24 across a variety of ecological settings, including plains and mountainous terrains, during different seasons. The study identified 66 wild mushroom species belonging to 31 families, with Agaricaceae being the most dominant, representing 30% of the collected species. To elucidate ecological relationships and environmental influences on mushroom distribution, statistical techniques such as cluster analysis, canonical correspondence analysis (CCA), and detrended correspondence analysis (DCA) were performed using PC-ORD and CANOCO software. The findings provide valuable insights for environmental conservation, sustainable harvesting practices, and maximizing the nutritional and commercial potential of wild mushrooms.

Keywords: *Ecology, fungal diversity, poisonous mushrooms, unexplored region*

Introduction

Fungi are considered the second most diverse biological community after insects (Steyeart*et al*. 1980). Mushrooms, classified under the kingdom Fungi, belong to the classes Ascomycetes and Basidiomycetes. They are characterized by well-developed nuclei, and their main body, known as mycelium, consists of thread-like structures called hyphae. Under favourable environmental conditions, such as optimal temperature and humidity, the mycelium produces fruiting bodies, commonly known as mushrooms (Chaudhary *et al*., 2015).Recent estimates suggest that there are approximately 5.1 million fungal species worldwide (Blackwell, 2011). Wild edible mushrooms have been utilized for both food and medicinal purposes for thousands of years. Globally, around 2,327 mushroom species have been recorded for their utility, with 2,166 species identified as edible. Of these, 1,069 species are commonly used as food, and at least another 100 species are known to be edible but lack sufficient evidence (Boa, 2004). According to (Mizuno, 1993; Wasser, 1995; Ferreira *et al*., 2010) nearly 700 species of Basidiomycetes fungi exhibit significant ethnopharmacological activities. Wild edible mushrooms are harvested and sold in over 80 countries worldwide (Boa, 2004).

The diversity of wild mushroom species varies according to environmental factors such as nutrient availability, particularly nitrogen, moisture content in soil and air, and vegetation types (O'Hanlon and Harrington, 2012; Pradhan *et al*., 2013). Mushrooms typically produce their fruiting bodies in specific seasons, inhabiting different ecosystems within forests (Stamets, 2000). One of the critical ecological roles of mushrooms is their function as ectomycorrhizal fungi, which play a significant part in forest cultivation programs. Additionally, macrofungi serve as bioindicators of environmental quality (Andrew *et al*., 2013). The main objective of the current study was to investigate the species diversity and ecological distribution of macrofungi in District Swabi, Khyber Pakhtunkhwa, Pakistan.

Materials & Methods

Sampling site

The fruiting bodies of various wild mushrooms were collected from both plain and hilly regions of District Swabi in the province of Khyber Pakhtunkhwa, Pakistan. This district is located adjacent to the Indus River and can be pinpointed at the coordinates ''34°7'0N, 72°28'0E''(Fig. 1). District Swabi covers an area of 1,543 square kilometers, which is approximately 595.8 square miles. The average annual temperature is 22.2°C, and the average annual precipitation is 639 mm. November is the driest month, with an average rainfall of 12 mm, while August is the wettest, receiving an average of 137 mm of precipitation(Anwar *et al*., 2015).

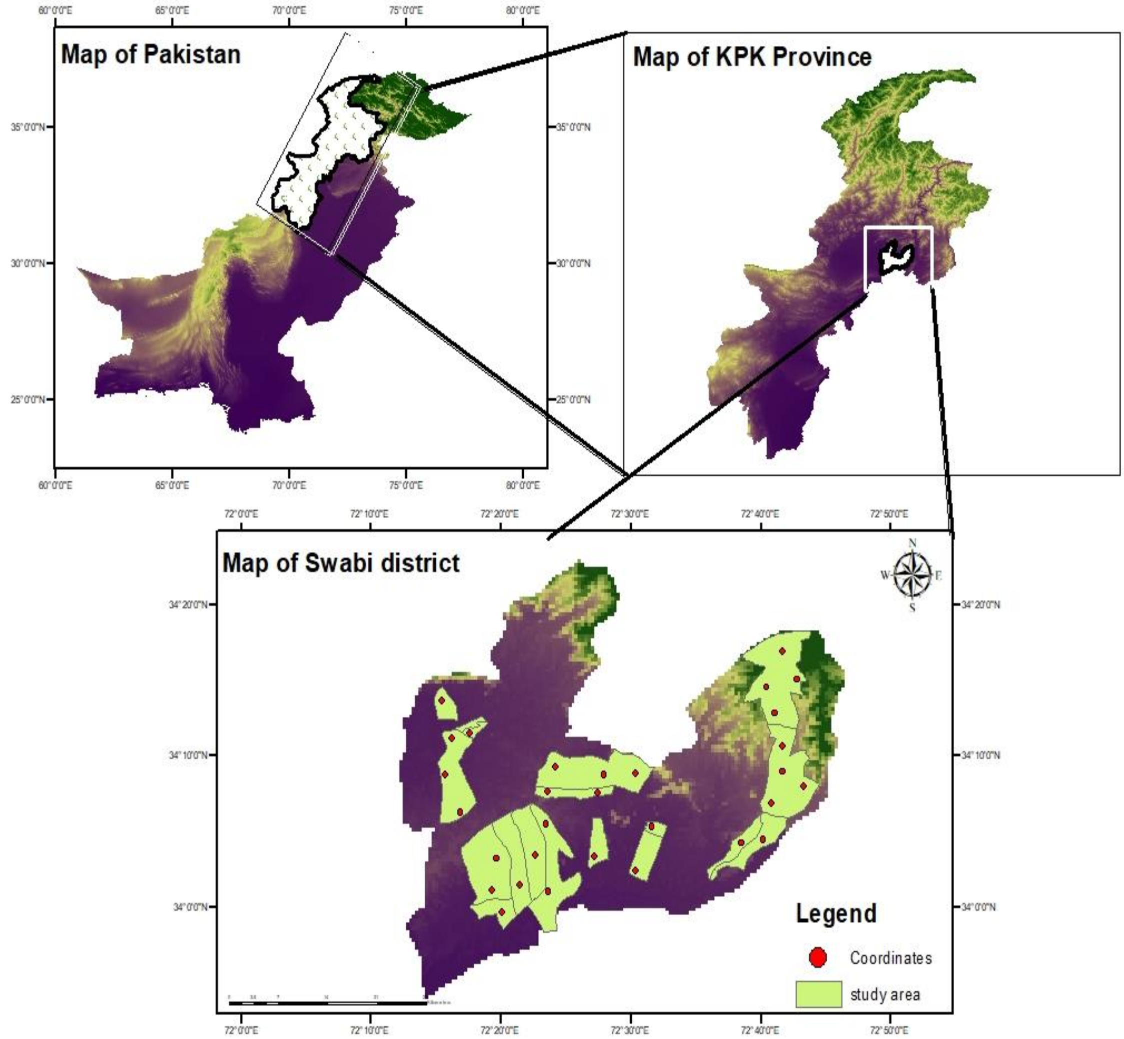

Fig. 1.Map showing the sampling sites of the study area.

Data Collection

Quadrat-based quantitative ecological methodwere used to collect macro-fungi and their associated ecological data during 2022-2024(Khan *et al*., 2011a).A GPS device was used to measure altitude and a digital compass determined the slope aspect (East, West, South, or North). Soil samples were collected from each site to a depth of 15 cm, mixed to form composite samples, stored in labelled polythene bags, and transported to the Plant Ecology and Conservation Laboratory, Department of Plant Sciences, Quaid-i-Azam University, Islamabad, for further analysis.Taxonomists and mycologists, along with the use of available published literature, assisted in the identification of specimens, which were then preserved in the Herbarium of Quaid-i-Azam University, Islamabad, Pakistan.

Data analysis

Species and environmental data sets were processed in MS Excel in accordance with the requirements of PCORD V.5. Data collected from 20 sampling sites (66 quadrats) revealed the presence of 66 mushroom species. These species data, along with seven environmental variables such as altitude, slope, aspect, soil organic matter, soil pH, soil electrical conductivity, and moisture content were analyzed using PCORD version 5 (McCune and Mefford, 1999). Cluster Analysis (CA) and Two-Way Cluster Analysis (TWCA) were conducted to identify significant habitat and fungi community types using Sorensen measures based on presence/absence data (Greig-Smith, 1983), revealing patterns of similarity in species and station data. To assess the effects of various environmental variables on the composition, distribution, and abundance of the mushroom species, ordination analyses, including Canonical Correspondence Analysis (CCA) and Detrended Correspondence Analysis (DCA), were performed using CANOCO software version 4.5 (Anwar *et al*., 2019). In the laboratory, soil samples were analyzed for pH, electrical conductivity (EC), total dissolved solids (TDS), moisture content and organic matter content. Soil pH was measured using a pH meter (Jackson *et al*., 1962), while EC was determined using an electrical conductivity meter (Rhoades *et al*., 1990). TDS was calculated based on EC readings, following the methodology of (Richard, 1954).

Results & Discussion

The district Swabi remains largely unexplored with respect to the diversity, habitat, and potential uses of wild mushrooms. To address this gap, a comprehensive survey was conducted across various plain and hilly regions of the district from 2022 to 2024, following periods of rainfall. In hilly areas such as Gadoon, Beer Gali, Besak, Utla, Kabghani, Bada, Takeel, Sandowa, and Gani Chatra, the majority of wild mushrooms were found to produce fruiting bodies primarily in August and September. In contrast, in the plain areas including Lahor, Yar Hussain, Adina, Kalu Khan, and Shewa, mushroom diversity peaked in July, August, and December following heavy rainfall. During the field survey, a total of 66 wild mushroom species (Tab.1) were collected and identified to the species level, representing 31 different families following established methodologies (Figs 2a,2b,2c,2d) (Yusran*et al*., 2021). Previously documented species were morphologically verified using published descriptions (Dwivedi *et al*. 2015). The dominant family identified was Agaricaceae, with 20 species (30%), followed by Amanitaceae and Psathyrellaceae, each with 4 species (6%), Inocybaceae with 3 species (5%), and both Russulaceae and Diplocystaceae, each with 2 species (3%). Wild mushroom species exhibited significant variation in habitat preference. Approximately 41% of the species were found growing on soil, 24% on dead wood, 20% on trees, and the remaining 15% on dung. These findings provide crucial insights into the ecological diversity of mushrooms in the district and open new avenues for exploring their ecological, nutritional, and medicinal potential.

Figure 2a.Field photographs 1-20 of collected mushrooms (Species names are mentioned in table 1).

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Figure 2b.Field photographs 21-40 of collected mushrooms, (Species names are mentioned in Table 1).

Figure 2c.Field photographs 41-60 of collected mushrooms, (Species names are mentioned in Table 1).

Figure 2d.Field photographs 61-66 of collected mushrooms, (Species names are mentioned in Table 1).

Mushrooms edibility in district Swabi

The district of Swabi, located in a region with fertile soil, is home to a diverse array of wild mushrooms. These mushrooms have been categorized into different groups based on their edibility, with 36% being edible, 23% non- edible, 21% poisonous, and 3% remaining unidentified. The presence of edible mushrooms, such as *Morchella esculenta*, *Agaricus propeaugustus*, *Agaricus bitorquis*, and *Agaricus subpinus*, has made them a valuable food resources for the local rural population.

Comparison between plain and hilly areas

There is a contrast in the familiarity and reliance on wild mushrooms between the inhabitant of plain areas and those in hilly areas (specifically Gadoon). In the plain areas, people are not highly familiar with wild mushrooms and do not heavily depend on them for sustenance. In contrast, people living in the hilly areas, like Gadoon, have a closer relationship with wild mushrooms and utilize them as a food source. Their reliance on wild mushrooms is particularly linked to rainfall patterns, as certain edible mushrooms only produce their fruiting bodies after heavy rainfall (Yaseen *et al*.,2016). The occurrence of poisonous wild mushrooms in hilly regions presents a considerable threat to local communities, particularly because these toxic species often bear a close resemblance to edible varieties. This risk was tragically highlighted by a recent incident in which two young boys succumbed after ingesting toxic mushrooms, mistakenly consumed as food. This unfortunate event emphasizes the critical need for accurate mushroom identification and public awareness initiatives to educate the population on the potential dangers of foraging wild mushrooms.

Threats to mushroom diversity

The rich diversity of mushrooms in the study areas is increasingly at risk due to a range of anthropogenic pressures. Key threats include deforestation, overgrazing by livestock, road construction, urban expansion, and the widespread use of chemical fertilizers for agricultural enhancement. Additionally, there is a notable lack of awareness and interest among the local population regarding the conservation of mushroom biodiversity. These human activities are contributing to the degradation of natural habitats.

Ecological Study

Cluster analysis

The cluster analysis was performed using PCORD version 5. It classified all the 66 quadrates and 66 species into four major communities based on Sorensen distance measurements Distance in District Swabi, Khyber Pukhtunkhwa, Pakistan(Fig. 3).

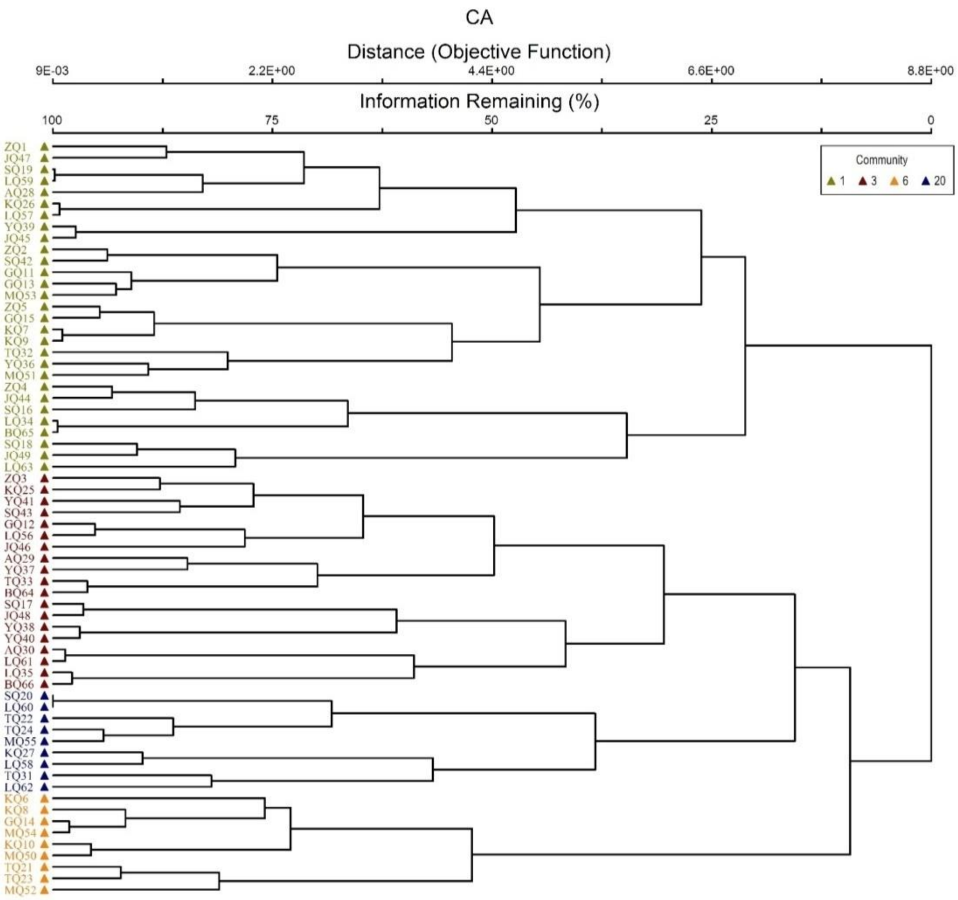

Figure 3. Cluster dendrogram of 66 quadrates showing 4 Macro-fungi communities based on Sorensen distance measurement.

Two way cluster analysis

Two-way cluster Analysis (TWCA) was employed to show the quadrate wise distribution of mushrooms species. In the quadrate, green dots indicate the occurrence of specific species of mushrooms, whereas white dots indicate their absence(Fig. 4).

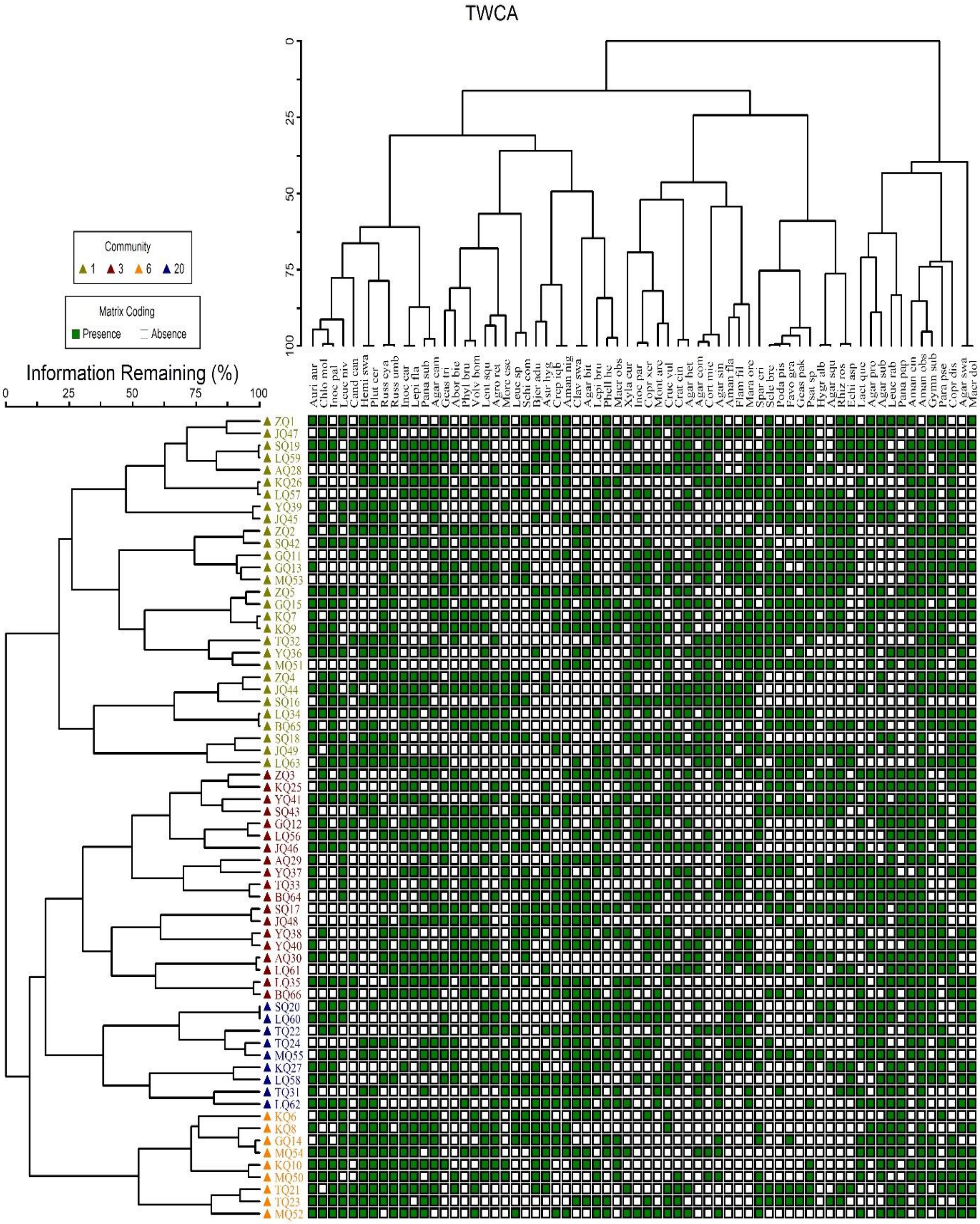

Figure 4. Two-way cluster analysis dendrogram of 66 species and 66 quadrates based on Sorensen measures representing groups of mushrooms species and quadrats through PC-ORD version 5.

Environmental gradient

Ordination techniques such as DCA and CCA were implemented using CANOCO software version 4.5 to analyze the ecological data. The relationship between mushroom species and soil variables was examined through the CANOCO program. The environmental factors, specifically the edaphic variables, had a significant influence on the diversity, abundance, and distribution of the mushroom species.

Canonical correspondence analysis for species

Canonical Correspondence Analysis (CCA) was performed using CANOCO software to examine the relationships between environmental variables and mushroom species distribution. The environmental factors analyzed included soil pH, electrical conductivity, total dissolved solids (TDS), organic matter, slope, moisture content, and altitude. The first quadrant of the CCA biplot indicated a strong correlation between species and environmental variables. In the second quadrant, most species were clustered around soil pH, TDS, and slope, indicating a positive influence of these factors on species distribution. In the third quadrant, altitude, moisture content, vegetation cover, and electrical conductivity were the primary variables influencing species. The fourth quadrant showed that organic matter was the dominant factor affecting species distribution (Fig. 5).

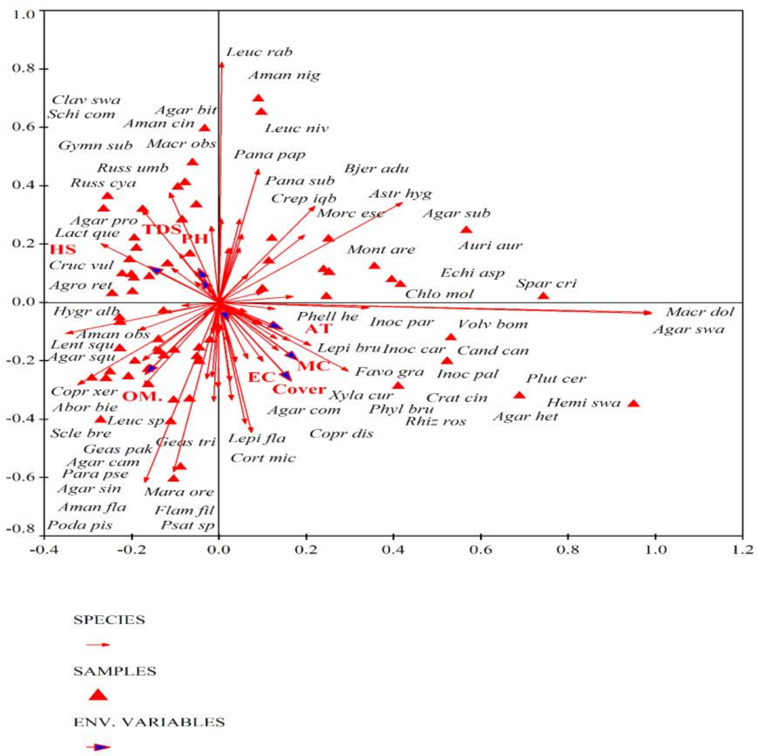

Figure 5. CCA data attribute plot representing all the mushrooms species under impact of various environmental variables.

Detrended canonical correspondence analysis for species.

DCA is a variation of correspondence analysis (CA) used to identify the underlying gradients in the species data without any correlated to environmental variables. A closely associated group of *Auricularia auricula-judae*, *Agaricus comtulus*, *Leucoagaricus nivalis*, *Morchella esculenta*, *Agrocyberetigera*, *Russula umbra*, *Bjerkanderaadusta*, *Bjerkanderaadusta* are present on the left side of x-axis. While *Psathyrella specie*, *Inocybe pallida*, *Russulacyanoxantha*, *Lepiotabrunneoincarnata*, *Schizophyllum commune*, *Panaeolussubbalteatus*formed comparatively associated group at the top left side.While the second quadrate showed that *Hygrophorusalbo flavescens*, *Gymnopussubnudus*, *Lentinus squarrosulus*, *Abortiporusbiennis*, *Podaxispistillaris*, *Coprinellus disseminates*, *Scleroderma brevistipetus*. The third quadrate showing the majority of species*Cortinariusmicrocarpus*, *Craterellus cinereus*, *Candolleomycescandolleanus*, *Xylariacurta*are grouped around the left x-axis of the quadrate. While the majority of species*Inocybe pallida*, *Agaricus swaticus*are grouped around the right side of x-axis. The fourth quadrate showing the distribution of species*Geastrum triplex*, *Parasolapseudolactea*, *Marasmiusoreades* (Fig.6).

Figure 6. DCA diagram illustrating the distribution of species.

Conclusion

The finding of the current studiesshowed that district Swabi environmental conditions were more suitable for the growth of mushrooms species. Additionally, the results of the study provided more evidence that mushrooms species growth were significantly higher in the Swabi.In mountainous areas, the growing season of wild mushrooms was at peak in August and September, whereas in plain areas, the diversity was more pronounced in July, August, and December after significant rains. Environmental research and conservation initiatives can benefit from an understanding of the distribution of mushroom families.

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Table 1. List of wild mushroom species with their common names, habitat, locality, growing season, and edibility collected from plain and hilly areas of District Swabi.

S.No	Name	Common Name	Family	Locality	Host	Seasonality	Edibility status	Reference
1	*Abortiporusbiennis*	Blushing rosette	Meruliaceae	Jagan Nath	Muddy soil/wood	July-September	Non edible	(Singer, 1944)
2	*Agaricus abietis*	button mushroom	Agaricaceae	Jalsai	Soil humus	August-September	Edible	(Batsch, 1783)
3	*Agaricus abramsii*	button mushroom	Agaricaceae	Inbar	wood logs and manure piles	July-August	Edible	(Murrill, 1912)
4	*Agaricus bisporus*	button mushroom	Agaricaceae	Jalbai	Sandy soil	August-September	Edible	(Imbach, 1946)
5	*Agaricus bitorquis*	Pavement Mushroom	Agaricaceae	Kota	Road bank/grassy field	April-August	Edible	(Saccardo, 1887a)
6	*Agaricus campestris*	meadow mushroom	Agaricaceae	Jagan Nath	Grassy field after heavy rain	July-September	Edible	(Linnaeus, 1753)
7	*Agaricus comtulus*	Mini mushroom	Agaricaceae	Gandaf	Soil	June-August	Edible	(Fries, 1838)
8	*Agaricus heterocystis*	meadow mushroom	Agaricaceae	Maneri	Sandy and loamy soil	August-October	Edible	(Heinemann, 1956)
9	*Agaricus sinodeliciosus*	button mushroom	Agaricaceae	Utla	Waterlogged soil/rice crop	July-December	Edible	(Zhuo and Zhao 2015)
10	*Agrocyberetigera*	Spring Fieldcap	Strophariaceae	Dobyan	Sandy soil/ above wood	July-August	Poisonous	(Singer, 1951)
11	*Amanita abietum*	fly amanita	Amanitaceae	Maneri	Humus of pine forest	August-September	Poisonous	(Gilbert, 1929)
12	*Amanita abrupta*	royal fly agaric	Amanitaceae	Besak	Soil grassy field / live wood	April-July	Poisonous	(Peck, 1897)
13	*Amanita echinocephala*	*stinking dapperling*	Agaricaceae	Gandaf	Rich humus/dead and living wood	August-October	Non edible	(Quélet, 1872)

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14	*Amanita cinis*	*fly agaric*	Amanitaceae	Sodier	On ground pine forest	July-September	Non edible	(Ullah*et al.*, 2019)
15	*Amanita flavipes*	fly agaric or fly amanita	Amanitaceae	Beer gali	Soil/ dead wood	April-July	Poisonou s	(Imai, 1933)
16	*Astraeus hygrometricus*	hygroscopic earthstar	Diplocystaceae	Utla	Loamy soil/dead wood	December-April	Edible	(Morgan, 1889)
17	*Auricularia cornea*	Jelly Ear Fungus	Auriculariaceae	Jamra	Dead tree	December-February	Edible	(Ehrenb, 1820)
18	*Bjerkanderaadust a*	Smoky polypore/smoky bracket	Meruliaceae	Ghani chatra	Soil	July-September	Non edible	(Karst, 1879)
19	*Candolleomycesa berdarensis*	Crumble Cap	Psathyrellaceae	Gaddon	Sandy soil/wood	August-October	Edible	(Wächter and Melzer 2020)
20	*Cantharellus cinereus*	Black Trumpet, Horn of Plenty,	Cantharellaceae	Jagan Nath	Association with populous tree roots/soil	August-November	Edible	(Pers, 1794)
21	Chlorophyllum abruptibulbum	flowerpot parasol	Agaricaceae	Kalu khan	*decayed plant matter humus*	June-August	Poisonou s	(Vellinga, 2002)
22	*Chlorophyllum molybdites*	false parasol Mushroom	Agaricaceae	Yar hussain	Grassy field/garden lawn	July-September	Poisonou s	(Massee, 1898)
23	*Clavulinacoralloi des*	*white coral fungus*	Clavulinaceae	Adina	Ground soil/ pine forest	October-March	Edible	(Schröter, 1888)
24	*Coprinellusallove lus*	fairy inkcap	Psathyrellaceae	Manki	Shaded area of populous trees	March-May	Edible	(Doveri*et al.*, 2010)
25	*Coprinus xerophilus*	*shaggy ink cap*	Agaricaceae	Jasai	*dung or manured soil/ grassland*	July-December	Poisonou s	(Bogart ,1976)
26	*Cortinariusaavae*	*gypsy mushroom*	Cortinariaceae	Jagan Nath	Pine forest/ wood	July-October	Poisonou s	(Niskanen *et al.*,2012)
27	*Crepidotusiqbalii*	*peeling oysterling*	Crepidotaceae	Besak	dead twigs of populous tree	July-October	Non edible	(Izhar *et al.*, 2021)
28	*Crucibulumvulga*	bird's-nest fungi	Nidulariaceae	Gandaf	*dead stems of morus /*	August-	Non	(Tulasne andTulasne 1844)

	re				*muddy soil*	November	edible	
29	*Echinoderma asperum*	freckled dapperling	Agaricaceae	Gaddon	Leaf humus/ dead wood	June-July	Edible	(Bon, 1991)
30	*Favolusgrammocephalus*	*honeycomb fungus*	Polyporaceae	Topi	Above dead and living trees	July-September	Edible	(Lloyd, 1924)
31	*Flammulinafiliformis*	golden needling mushroom	Physalacriaceae	Maneri	Dead wood	August-September	Edible	(Wang *et al.*,2018)
32	*Geastrumaculeatum*	*rounded earthstar*	Geastraceae	Beer gali	litter humus of pine forest	October and March	Unknown	(Silva and Baseia 2013)
33	*Geastrum triplex*	Earth star fungi	Diplocystaceae	Sandwa	Soil	September-November	Non edible	(Jung, 1840)
34	*Gymnopussubnudus*	Collybiasubnuda	Omphalotaceae	Jagan nath	leaf litter of pinus tree/decomposer	October-March	Edible	(Antonín *et al.*, 1997)
35	*Hemileccinumimpolitum*	iodine bolete	Boletaceae	Utla	Soil/dead and live wood	August-October	Edible	(Šutara, 2008)
36	*Hygrophorusalboflavescens*	*ivory waxy cap*	Hygrophoraceae	Gandaf	Soil/dead and live wood	August-October	Edible	(Naseer *et al.*, 2019)
37	*Infundibulicybe squamulosa*	field mushroom	Agaricaceae	Ghani chatra	Soil humus/ pine forest floors	April- June	Edible	(Harmaja, 2003)
38	*Inocybe aberrans*	white inocybe	Inocybaceae	Kalu khan	Above pine tree	June-September	Non edible	(Garrido, 1988)
39	*Inocybecaroticolor*	*Beige Fibrecap*	Inocybaceae	Jalsai	Association with pine tree/soil	June-September	Non edible	(Fan and Bau 2013)
40	*Inocybe pallida*	white fibercap fungus	Inocybaceae	Jalbai	Loamy soil/ above other tree	August-October	*deadly poisonous*	(Velen, 1920)
41	*Lactarius aberrans*	*milk-caps mushroom*	Tricholomataceae	Besak	Grassy field soil/above wood	March-October	Non edible	(Bon, 1980)
42	*Lentinus squarrosulus*	Tiger Sawgill fungus	Polyporaceae	Gandaf	Soil/ dead wood	July-October	Edible	(Mont, 1842)
43	*Lepiotabrunneoincarnata*	deadly dapperling	Agaricaceae	Utla	Garden lawn /soil	April-June	Poisonous	(Chodat and Martín 1889)
44	*Leucoagaricus*	*white Agaricus*	Agaricaceae	Ghabasni	Loamy soil/humus	October-	Non	(Singer, 1973)

	acaciarum	*mushroom*				November	edible	
45	*Leucoagaricus nivalis*	White Dapperling	Agaricaceae	Berr gali	Soil/ dead wood	December-February	Edible	(Ge and Yang 2017)
46	*Macrocystidiacucumis*	*Cucumber Cap*	Marasmiaceae	Sandwa	Grassy field	April- June	Non edible	(Josserand, 1934)
47	*Macrolepiota dolichaula*	slender parasol	Agaricaceae	Gadoon	Grassy field	December-April	Edible	(Taylor, 2001)
48	*Marasmiusoreades.*	fairy ring mushroom	Marasmiaceae	Lahor	Beneath pine tree	October-March	Edible	(Fries, 1836)
49	*Montagnea arenaria*	Desert inkcap	Agaricaceae	Manki	Forest soil/dead wood	February-March	Non edible	(Zeller, 1943)
50	*Morchella esculenta*	sponge morel	Morchellaceae	Jalbai	Sugarcane field/ burned areas	April-December	Edible	(Pers, 1794)
51	*Panaeoluspapilionaceus*	Petticoat mottlegill	Bolbitiaceae	Besak	manured soil/grazed land	October-March	Unknown	(Quél, 1872)
52	*Panaeolussubbalteatus*	banded mottlegill	Bolbitiaceae	Beer gali	horse dung	June-August	Poisonous	(Saccardo, 1887b)
53	*Parasolapseudolactea*	Pleated Inkcap	Psathyrellaceae	Lahor	Grassy area/decomposer	August-September	Non edible	(Shah *et al*.,2018)
54	*Phelloriniaherculeana*	maru khumbhi	Phelloriniaceae	Inbar	Sandy soil	June-August	Edible	(Kreisel, 1961)
55	*Phylloporusbrunneiceps*	*gilled bolete*	Boletaceae	Topi	Muddy soil/dead wood	July-September	Edible	(Zeng *et al*.,2013)
56	*Pluteus cervinus*	Deer Shield mushroom	Pluteaceae	Shewa	Decomposer of wood debris	June-August	Edible	(Kumm, 1871)
57	*Podaxispistillaris*	desert shaggy mane	Agaricaceae	Gandaf	Muddy soil	August-October	Edible	(Lundae, 1829)
58	*Psathyrellaspadicea*	Crumble cap	Psathyrellaceae	Kunda	Grown on roots/grassy fields	August-October	Edible	(Singer, 1951)
59	*Rhizopogonroseolus*	Shoro mushrooms	Rhizopogonaceae	Gandaf	Rocky soil/dead wood	March-April-	Edible	(Fries, 1909)

						September-October		
60	*Russulaabietina*	brittle gills	Russulaceae	Hund	Grassy field/shaded area of pines trees	June-September	Poisonous	(Peck, 1902)
61	*Russulacyanoxantha*	charcoal burner	Russulaceae	Gandaf	Attached with pine tree root/soil	June –July	Edible	(Schaeff,1863)
62	*Schizophyllum commune*	split gill fungus	Schizophyllaceae	Beer gali	Mostly found on dead wood	June-September	Edible	(Fries, 1815)
63	*Scleroderma albidum*	*common earth ball mushroom*	Sclerodermataceae	Yar hussain	sandy soil, forest tracks	May-June	Poisonous	(Pat and Trab 1899)
64	*Sparassiscrispa*	Cauliflower mushroom	Sparassidaceae	Sodier	Sandy soil	July – September	Edible	(Fries, 1821)
65	*Volvariella bombycina*	Silky Rosegill	Pluteaceae	Tarbella	Decomposer of dead hardwoods	July-August	Edible	(Schaeff and Singer 1951)
66	*Xylariacurta*	Dead man finger fungi	Xylariaceae	Jagan nath	Dead tree/soil	July-September	Non edible	(Fries, 1855)

References

Andrew, E. E., Kinge, T. R., Tabi, E. M., Thiobal, N., & Mih, A. M. (2013). Diversity and distribution of macrofungi (mushrooms) in the Mount Cameroon Region. *Journal of Environmental Microbiology, 3,* 318–334.

Antonín, V., Halling, R. E., &Noordeloos, M. E. (1997). Generic concepts within the groups of *Marasmius* and *Collybia sensu lato*. *Mycotaxon, 63*, 365.

Anwar, M., Khan, W. M., Khan, M. S., Murad, W., & Ali, S. (2015). Taxonomic study of Family Papilionaceae of District Swabi, Khyber Pakhtunkhwa, Pakistan. *Pure and Applied Biology, 4*(1), 125–128.

Anwar, S. S., Khan, M., Ahmad, Z., Ullah, Z., & Iqbal, M. (2019). Floristic composition and ecological gradient analyses of the Liakot Forests in the Kalam region of District Swat, Pakistan. *Journal of Forest Research, 30*(4), 1407–1416.

Batsch. (1783). *Elenchus fungorum*. Halle: Agaricus pluteus 79. Source: Species Fungorum Plus.

Blackwell, M. (2011). The fungi: 1, 2, 3 … 5.1 million species? *American Journal of Botany, 98*, 426–438.

Boa, E. R. (2004). *Wild edible fungi: A global overview of their use and importance to people*. Food & Agriculture Organization.

Bogart. (1976). In *Mycotaxon, 4*(1), 255. Source: Species Fungorum Plus.

Bon, M. (1991). Les genres *Echinoderma* (Locq. ex Bon) st.nov. et *Rugosomyces*Raithelhuber ss. lato. *Documents Mycologiques, 21*(82), 62.

Bon. (1980). *Documents Mycologiques, 10*(40), 19. *Lactarius aberrans*.

Bull, Quél. (1872). In *Mémoires de la Société Botanique de France*, Séries 2, *5*, 152 [122 repr.]. Source: Species Fungorum Plus.

Chen, J., Zhao, R. L., Parra, L. A., Guelly, A. K., Kesel, A. D., Rapior, S., Hyde, K. D., Chukeatirote, E., & Callac, P. (2015). *Agaricus* section *Brunneopicti*: A phylogenetic reconstruction with descriptions of four new taxa. *Phytotaxa, 192*, 145–168.

Chodat, M. (1889). In *Bulletin de la Société Botanique de Genève*, 2nd series, *5*, 222. Source: Species Fungorum Plus.

Choudhary, M., Devi, R., Datta, A., Kumar, A., & Jat, H. S. (2015). Diversity of wild edible mushrooms in Indian subcontinent and its neighboring countries. *Recent Advances in Biology and Medicine, 1*, 69–76.

Curtis, J. T., & McIntosh, R. P. (1950). The interrelations of certain analytic and synthetic phytosociological characters. *Ecology*, 434–455.

Da Silva, B. D. B., Cabral, T. S., Marinho, P., Ishikawa, N. K., & Baseia, I. G. (2013). Two new species of *Geastrum* (Geastraceae, Basidiomycota) found in Brazil. *Nova Hedwigia, 96*(3–4), 445–456.

Doveri, F., Sarrocco, S., Pecchia, S., Forti, M., &Vannacci, G. (2010). *Coprinellusmitrinodulisporus*, a new species from chamois dung. *Mycotaxon, 114*, 351–360. https://doi.org/10.5248/114.351

Dwiwedi, S., Singh, S., Chauhan, U. K., & Tiwari, M. K. (2015). First report on the unreported macrofungal diversity of Vindhyan Region of central India with special reference to Agaricales. *International Research Journal of Environmental Sciences, 4*(8), 50–59.

Ehrenb. (1820). In C. G. D. Nees von Esenbeck (Ed.), *Horae PhysicaeBerolinenses* (p. 91). Species Fungorum Plus.

Fan, Y. G., & Bau, T. (2013). Two striking *Inocybe* species from Yunnan Province, China. *Mycotaxon, 123*(1), 169–181.

Ferreira, I. C. F. R., Vaz, J. A., Vasconcelos, M. H., & Martins, A. (2010). Compounds from wild mushrooms with antitumor potential. *Anti-Cancer Agents in Medicinal Chemistry, 10*, 424–436.

Fr. (1815). *ObservationesMycologicae* (Vol. 1, p. 103). Havniae. Species Fungorum Plus.

Fr., Lundae. (1829). *Systema Mycologicum*, 3(1), 63. Species Fungorum Plus.

Fries, E. M. (1821). *Systema Mycologicum, sistensfungorum ordines, genera species* (Vol. 1). Sumtibus Ernesti Mauritii.

Fries, E. M. (1836). In *Anteckningaröver de Svenska ätligaSvamparna* (p. 52). Catalogue of Life.

Fries, E. M. (1838). In *EpicrisisSystematisMycologici* (p. 215). Upsaliae.

Fries, T. M. (1909). *SkandinaviensTrygfflarochtryffelliknandesvampar (Fungi hypogaei). Svensk BotaniskTidskrift, 3*, 224–300.

Garrido, N. (1988) Agaricales s.l. und ihreMykorrhizen in den Nothofagus-WäldernMittelchiles: In: Biblthca Mycol. 120:176. - via Catalogueof Life

Ge, Z. W., Yang, Z. L., Qasim, T., Nawaz, R., Khalid, A. N., & Vellinga, E. C. (2017). Four new species in *Leucoagaricus* (Agaricaceae, Basidiomycota) from Asia. *Mycologia, 107*(5).

Gilbert, E. J. (1929). In Konrad (Ed.), *Bulletin Trimestriel de la Société Mycologique de France*, *45*(1), 35. Species Fungorum Plus.

Greig-Smith, P. (1983). *Quantitative plant ecology* (Vol. 9). University of California Press.

Harmaja. (2003) *Infundibulicybe squamulosa* (Pers.) Published in: (2003). Ann. Bot. Fenn. 40(3): 217. Source: Catalogue of Life

Heer. (2005). *Divisions & Subdivisions of Pakistan*.

Heinemann, P. (1956). Champignons récoltés au Congo Belge par Mme M. Goossens-Fontana, II. *Agaricus*, Note complémentaire. *Bulletin du Jardin Botanique de l'État, 26*, 325–333.

Horak, G. (1988). *Bibliotheca Mycologica, 120*, 176. Species Fungorum Plus.

Imai, S. (1933). Studies on the Agaricaceae of Japan I: Volvate agarics in Hokkaido. *Botanical Magazine (Tokyo), 47*, 423–432.

Imbach, E. J. (1946). Pilzflora des Kantons Luzern und der angrenzendenInnerschweiz. *Mitteilungen der Naturforschenden Gesellschaft in Luzern, 15*, 5–85.

Izhar, A., Usman, M., & Khalid, A. N. (2021). *Crepidotusiqbalii* (Crepidotaceae, Agaricales): A new stipitate species from Pakistan. *Phytotaxa*, *500*(2), 95–107.

Jackson, M. L. (1962). *Soil chemical analysis*. Constable Co., Ltd.

Joseph, S. (1888). In Cohn, *Kryptogamenflora von Schlesien* (Vol. 3.1[25–32], p. 443).

Josserand, M. (1934). Notes critiques sur quelques champignons de la région lyonnaise. *Bulletin Trimestriel de la Société Mycologique de France, 49*(3–4), 340–376.

Jungh. (1840). In *TijdschriftvoorNatuurlijkeGeschiedenisenPhysiologie, 7*, 287. Species Fungorum Plus.

Kang, J., Kang, Y., Ji, X., Guo, Q., Jacques, G., Pietras, M., &Łuczaj, Ł. (2016). Wild food plants and fungi used in the mycophilous Tibetan community of Zhagana (Tewo County, Gansu, China). *Journal of Ethnobiology and Ethnomedicine*, *12*(1), 1–13.

Karst. (1879). Bjerkandera adusta (Willd) Meddn Soc. Fauna Flora Fenn. 5: 38.source: Catalogue of Life

Khan, S. M., Harper, D. M., Page, S., & Ahmad, H. (2011). Species and community diversity of vascular flora along environmental gradient in Naran Valley: A multivariate approach through indicator species analysis. *Pakistan Journal of Botany, 43*, 2337–2346.

Kotowski, M. A., Pietras, M., &Łuczaj, Ł. (2019). Extreme levels of mycophilia documented in Mazovia, a region of Poland. *Journal of Ethnobiology and Ethnomedicine, 15*(1), 1–19.

Kreisel, (1961).*Phelloriniaherculeana* (Pers.) ČEskáMykol. 15(4): 196. In: Catalogue of Life

Kumm, (1871).*Pluteus cervinus* (Schaeff.) Führ. Pilzk. (Zerbst): 99. source: Catalogue of Life

Linnaeus, C. (1753). *Species Plantarum*, 2, 1173. Species Fungorum Plus.

Linnaeus, C. (1794). In *Neues Magazin für Botanik*, *1*, 116. Species Fungorum Plus.

Lloyd. (1924). *Mycological Writings* (Vol. 7, p. 1271). Cincinnati. *Favolusgrammocephalus*.

Mey, M. B. (1898). Miscellaneous information. *Kew Bulletin*, *138*, 136.

Mizuno, T. (1993). Food function and medicinal effect of mushroom fungi. *Foods and Food Ingredients Journal of Japan, 158*, 55–70.

Mont. (1842). In *Annales des Sciences NaturellesBotanique*, série 2, *18*, 21.

Morgan, A. P. (1889). North American fungi: The Gasteromycetes. *Journal of the Cincinnati Society of Natural History*, *12*, 8–22.

Murrill. (1912). *Agaricus abramsii*. In *Mycologia*, *4*(6), 298. Species Fungorum Plus.

Naseer, A., Khalid, A. N., Healy, R., & Smith, M. E. (2019). Two new species of *Hygrophorus* from temperate Himalayan oak forests of Pakistan. *MycoKeys, 56*, 33–47.

Niskanen, T., Liimatainen, K., Kytövuori, I., & Ammirati, J. F. (2012). New *Cortinarius* species from conifer-dominated forests of North America and Europe. *Botany, 90*(8), 743–754.

O'Hanlon, R., & Harrington, T. (2012). Macrofungal diversity and ecology in four Irish forest types. *Fungal Ecology, 5*, 499–508.

Pat, T. (1899). In *Bulletin Trimestriel de la Société Mycologique de France*, *15*(1), 57. Catalogue of Life.

Peck, C. H. (1897). In *Bulletin of the Torrey Botanical Club*, *24*, 138.

Peck. (1902). *Annual Report of the New York State Museum*, *54*, 180 ('1901'). Species Fungorum Plus.

Pers, H. (2003). *Annales BotaniciFennici*, *40*(3), 217. Species Fungorum Plus.

Pers, K. (1961). *ČeskáMykologie*, *15*(4), 196. Species Fungorum Plus. (Basionym: *Scleroderma herculeanum* Pers.)

Pers. (1794). In *Neues Magazin für Botanik*, *1*, 106. *Cantharellus cinereus*.

Pradhan, B. (2013). A comparative study on the predictive ability of the decision tree, support vector machine and neuro-fuzzy models in landslide susceptibility mapping using GIS. *Computers & Geosciences*, *51*, 350–365.

Quélet, L. (1872). In *Mémoires de la Société d'Émulation de Montbéliard*, Sér. 2, *5*, 321.

Raja, M. U., Gardezi, S. R. A., Irshad, G., Akram, A., &Bodlah, I. (2019). Study of macro-fungi belonging to order Agaricales of Poonch District Azad Jammu and Kashmir (AJK). *Pure and Applied Biology*, *8*(1), 27–33.

Rhoades, J. D., Miyamoto, S., & Westerman, R. L. (1990). Testing soils for salinity and sodicity. In *Soil Testing and Plant Analysis* (pp. 299–336).

Richard, L. A. (1954). *Diagnoses and improvement of saline and alkali soils* (Agriculture Handbook No. 60). USDA.

Saccardo, P. A. (1887a). In *Sylloge Fungorum* (Abellini), *5*, 1124. Catalogue of Life.

Saccardo, P. A. (1887b). In *Sylloge Fungorum* (Abellini), *5*, 998.

Schaeff, F. R. (1863). *MonographiaHymenomycetumSuecicae* (Vol. 2, pt. 2, p. 194). Upsaliae.

Schaeff, P., & Kummer, P. (1871). In *Führer für Pilzkunde* (p. 99). *Pluteus cervinus*.

Schröt, (1888).*Clavulinacoralloides* (L.) In Cohn, Krypt.-Fl. Schlesien (Breslau) 3.1(25–32): 443 (’1889′). In: Catalogue of Life

Sensu Taylor. (2001). *Fide Segedin & Pennycook*. CABI databases.

Shah, H., Habib, A., Ullah, S., Pfister, D. H., Sher, H., Haidar, A., & Khalid, A. N. (2018). The genus *Parasola* in Pakistan with the description of two new species. *MycoKeys, 30*, 41.

Singer, R. (1944). Notes on taxonomy and nomenclature of the polypores. *Mycologia, 36*(1), 65–69.

Singer, R. (1951). *Lilloa, 22*, 493. Species Fungorum Plus.

Singer, R. (1951). The "Agaricales" (mushrooms) in modern taxonomy. *Lilloa, 22*, 832.

Singer, R. (1973). *Diagnoses fungorumnovorumAgaricalium III. BeiheftezurSydowia, 7*, 1–106.

Singer. (1951). *MycoBank*. International Mycological Association. Retrieved October 14, 2012.

Sitotaw, R., Lulekal, E., & Abate, D. (2020). Ethnomycological study of edible and medicinal mushrooms in Menge District, Asossa Zone, BenshangulGumuz Region, Ethiopia. *Journal of Ethnobiology and Ethnomedicine, 16*(1), 1–4.

Stamets, P. (2000). The role of mushrooms in nature: Culturing mushroom mycelium on agar media. In *Growing Gourmet and Medicinal Mushrooms* (pp. 1011). Ten Speed Press.

Steyaert, R. L. (1980). Study of some *Ganoderma* species. *Bulletin du Jardin Botanique National de Belgique, 50*, 135–186.

Šutara, J. (2008). *Xerocomus*s.l. in the light of the present state of knowledge. *Czech Mycology*, *60*(1), 29–62.

Tabassum, Y., Mubashir, K., Muhammad, S., & Hussan, A. (2016). Morphological study of edible and non-edible mushrooms in District Swabi, Khyber Pakhtunkhwa, Pakistan. *Pure and Applied Biology, 5*(4), 889–894.

Tulasne, L. R., &Tulasne, C. (1844). Research on the organization and mode of fruiting of mushrooms of the *Nidulariaceae* tribe, followed by a monographic essay. *Annals of Natural Science: Botany*, 3rd Series, *1*, 41–107.

Ullah, S., Wilson, A. W., Tulloss, R. E., Fiaz, M., Mueller, G. M., & Khalid, A. N. (2019). *Amanita cinis* and *A. olivovaginata* (Basidiomycota, Amanitaceae), two new species, and the first record of *A. emodotrygon*, from Northwestern Pakistan. *Turkish Journal of Botany*, *43*(6), 831–849.

Ullah, T. S., Firdous, S. S., Mehmood, A., Shaheen, H., & Dar, M. E. (2017). Ethnomycological and nutritional analyses of some wild edible mushrooms from Western Himalayas, Azad Jammu and Kashmir (Pakistan). *International Journal of Medicinal Mushrooms, 19*(10).

Velen. (1920). In *České Houby, 2*, 366. *Inocybe pallida*. Species Fungorum Plus.

Wächter, D., & Melzer, A. (2020). Proposal for a subdivision of the family *Psathyrellaceae* based on a taxon-rich phylogenetic analysis with iterative multigene guide tree. *Mycological Progress*, *19*(11), 1151–1265.

Wang, P. M., Liu, X. B., Dai, Y. C., Horak, E., Steffen, K., & Yang, Z. L. (2018). Phylogeny and species delimitation of *Flammulina*: Taxonomic status of winter mushroom in East Asia and a new European species identified using an integrated approach. *Mycological Progress*, *17*(9), 1013–1030.

Yaseen, T., Khan, M., Shakeel, M., &Ara, H. (2021). 28. Morphological study of edible and non-edible mushrooms, district Swabi, Khyber Pakhtunkhwa, Pakistan. *Pure and Applied Biology (PAB), 5*(4), 889-894.

Yusran, Y., Erniwati, E., Wahyuni, D., Ramadhanil, R., & Khumaidi, A. (2021). Diversity of macro fungi across three altitudinal ranges in Lore Lindu National Park, Central

Sulawesi, Indonesia and their utilization by local residents. *Biodiversity Journal of Biological Diversity*, *22*(1).

Zeller, S. M. (1943). North American species of *Galeropsis*, *Gyrophagmium*, *Longia*, and *Montagnea*. *Mycologia*, *35*(4), 409–421.

Zeng, N. K., Tang, L. P., Li, Y. C., Tolgor, B., Zhu, X. T., Zhao, Q., & Yang, Z. L. (2013). The genus *Phylloporus* (Boletaceae, Boletales) from China: Morphological and multilocus DNA sequence analyses. *Fungal Diversity*, *58*, 73–101.

Zhou, J., Bai, X., & Zhao, R. (2015). Microbial communities in the native habitats of Agaricus sinodeliciosus from Xinjiang Province revealed by amplicon sequencing. *Scientific reports*, *7*(1), 15719.