



Original Research

Four Species of True Morels (*Morchella*) Recorded from Poonch District (Azad Jammu and Kashmir)

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ABSTRACT

A study was carried out in three administrative units (tehsils) of Poonch district of Azad Jammu and Kashmir (AJK) state to record the presence of true morels belonging to genus *Morchella* of class Ascomycetes. A periodic random survey was carried out during the year 2015-16. Distribution of four species of morels *Morchella esculenta* (40%), *M. elata* (30%), *M. deliciosa* (20%) and *M. semilibera* (10%) was recorded during survey period from February 15 to March 30. During rest of months of survey period no morel was observed in the same locations. The temperature during collection ranged between 3-7 °C. Morels were found growing under plant canopies, tree shades and on disturbed grass lands. To isolate, morels were dug out with the help of shovel and spade. Detailed macro and microscopic features such as stipe, pileus, spore shape and size were recorded. The minimum pileus diameter measured was about 1.0-2.5 cm in *M. semilibera*, while the maximum measurement of pileus diameter was 7.0-7.5 cm in *M. elata*. The minimum stipe length was about 1.5-5.0 cm in *M. deliciosa*, while the maximum measurement was observed 7.0-10.0 cm in *M. semilibera*. In addition, spore print (yellow, pale and black) was observed, while the maximum spore size was found in case of *M. semilibera*. The findings of this study showed the presence of four different species of morels in Poonch district of Azad Jammu and Kashmir.

Keywords: *Ascomycetes*, *Morchella esculenta*, *M. elata*, *M. deliciosa*, *M. semilibera*, spore size.

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INTRODUCTION

Wild edible fungi (WEF) are considered as special gift to mankind since ages. Mushroom enjoyed a special status in history as a whole civilization in ancient Greece was named after mushrooms called Mycenaean civilization. Wild mushroom hunting is still considered as rewarding experience in different parts of world, especially in Europe. Traditional Chinese medicine is full of uses of mushrooms. Ethnomycology is an emerging area in which academic fraternity around the globe showing immense interest. Due to excellent work and awareness campaigns, there is paradigm shift in societies towards WEF. Societies are becoming more and more mycophilic compared to mycophobic in past. Among WEF, morels are of pivotal importance because of their nutritional, medicinal and economic importance. Morels are the fruiting bodies of a soil inhabiting fungi belonging to genus *Morchella* (Pezizales, Morchellaceae, Ascomycetes). *Morchella* genus has been the source of considerable taxonomical controversies since ages. It is reported that there are about 70 species of *Morchella* worldwide including edible (true morels) and poisonous (false morels) species and most of them exhibiting high continental endemism and

provincialism (Alexopoulos et al., 1996; Boa, 2004; Kuo et al., 2012). Phylogenetic analysis showed that morels are oldest inhabitants and nearly 129 million years ago these diverged from fungal siblings (O'Donnell et al., 2011). There are few success stories of morel cultivation, but still vast majority come from wild (Masaphy, 2010). *Morchella* spp. are used in various cuisines because of peculiar taste, texture, and aroma. In addition, *Morchella* spp. are considered as the healthiest diet due to presence of polysaccharides, antioxidants, proteins, phytochemicals, phenols etc. Therefore, morels are traditionally used against inflammation, liver diseases, tumor, diabetes, infertility etc. (Tietel and Masaphy, 2018). Further, morels are excellent source of income in developing countries and livelihood of many communities depends on morel collection. WEF collection and sale provide additional income to rural communities of Himalayas in Pakistan, India, and Nepal (Boa, 2004).

Morels are the most prized fungi and there is great demand in international market. China exported 9,000 tons morel at astonishing price of \$160/kg (Du et al., 2015). Pakistan and India are also major exporters of morels as each country exporting 50 tons of morels annually. In Pakistan, morels are known as 'Guchhi'. Morels collection and marketing provide additional income to families in remote and impoverished areas of country. Almost 150,000 people are engaged in collection of morels in

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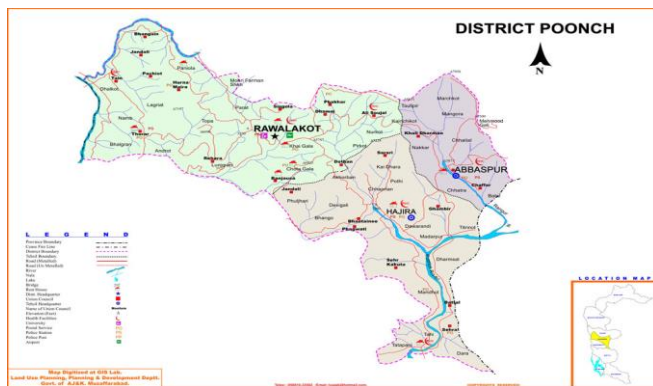


Figure 1: Map showing morel collection sites from three tehsils (Rawalakot, Abbaspur, Hajira) of Poonch district, Azad Jammu and Kashmir (AJK).

Pakistan. Morels are produced in Himalayas and these are mostly exported to European countries, which include Switzerland, France, Germany and Austria. Morel export is declining to climatic and anthropogenic disturbances (Sabra and Walter, 2001; Ciesla, 2002; Boa, 2004). Hindu-Kush mountain and Himalayas regions are best known for the morel collection. Being part of great Himalayas, Poonch district is also considered as one of global biodiversity hotspot because of its unique and unexplored flora and fauna (Zachos and Habel, 2011). There are reports on presence of macro-fungi and morels from Himalayas and Hindu-Kush mountain region of Pakistan, Afghanistan, India, Nepal, Bhutan and China (Latif et al., 2003; Christensen and Larsen, 2005; Hamayun et al., 2006; Negi, 2006; Lakhnawal et al., 2010). In past, presence of morels and other macro-fungi was mentioned in literature but still a lag phase exists when it comes to morels in Poonch region of Azad Jammu and Kashmir (Khan et al., 2010; Laala et al., 2019). Therefore, the present study was carried out to collect and identify morels present in different administrative units of Poonch valley. Identification was made both on the basis of microscopic and macroscopic features. The findings of the study can be helpful for future extensive studies about the exploration and conservation of natural treasure of the region.

MATERIALS AND METHODS

A periodic random survey was carried out in all three tehsils viz., Rawalakot, Hajira and Abaspur of Poonch District of Azad Jammu and Kashmir (Fig. 1) during the year 2015-16 to record the presence of true morels belonging to genus *Morchella* of class Ascomycetes. Standard methods were followed for collection and identification of morels. The morels were collected from soils under shade of trees especially under cypress canopies. In addition, morels were also found growing on grass lands. Photography was also done in natural habitat and temperature at collection sites was also recorded. Morels were picked from their habitat with the help of spade and garden shovel and

extreme care was taken to avoid damage to any part of the specimens. The morels were kept in polythene bags and were brought to the Department of Plant Pathology, University of the Poonch, Rawalakot and PMAS-Arid Agriculture University, Rawalpindi for further macroscopic and microscopic studies. The morels were preserved in dry (sunlight) and wet (formalin and 1% saline solution) forms. Pileus diameter and stipe length were measured and micrometry was done by measuring spore size by using ocular micrometer (Nikon Y200). The microscopic dimensions were based upon five measurements. Spore print was collected by cutting the fruiting body and later putting it on clean white paper. Spores were collected after cutting the pileus and stipe into two equal halves. Spores were picked very carefully with the help of small tweezers. After picking they were kept on glass slide and were observed under microscope for measuring their size and shape (Arora, 1986; Kuo, 2001).

RESULTS

Distribution of morels

During the present studies, four species of genus *Morchella* belonging to family Morchellaceae of order Pezizales and class Ascomycetes were collected from Rawalakot and Hajira tehsils of Poonch district growing at temperature recorded between 3-7 °C. However, no morel was found growing in Abbaspur tehsil during the same period. Nevertheless, morels were also not observed in other months of year from the same locations where previously found. All the four species were observed growing on soil. During collection, the intensity of the morels in Poonch district was *M. esculenta* (40%), followed by *M. elata* (30%), *M. deliciosa* (20%) and *M. semilibera* (10%) (Fig. 2).

Description of morels

The individual taxonomic and microscopic description of morel species collected from the Poonch district is as follows.

***Morchella esculenta* (Yellow morels):** *M. esculenta* was found in clustered and scattered form in a variety of habitats like old orchards, stream sides, long grasses, under conifer and cypress trees, in cultivated and disturbed grounds and even along roadsides. The cap is oval in shape with irregular pits. Spore print was seen pale/yellow colored (Fig. 3a). Morphological characteristics such as pileus diameter (5.0-7.0 cm) and length of stipe (5.5-8.0 cm) were examined and recorded. Spore size measured was 19-11 × 7-10 μm (Table 1).

***Morchella elata* (Black morels):** *M. elata* was collected from Poonch area of Azad Jammu and Kashmir in form of groups (Fig. 3b). It was seen on disturbed grounds in woods and at their edges, under conifer trees, cypress trees and in burned areas especially during February 2015. Spore print appeared was black in color (Fig. 3b). Morphological description including pileus diameter was 7.0-7.5 cm and length of stipe was measured

Table 1: Temperature range and morphological features of morels recorded from Poonch District of Azad Jammu and Kashmir.

Scientific name	Edibility	Temp. (°C)	Pileus diameter (cm)	Stipe length (cm)	Spore print	Spore size (μm)
<i>M. esculenta</i>	Edible	5	5.0-7.0	5.5-8.0	Yellow	9-11 × 7-10
<i>M. elata</i>	Edible	7	7.0-7.5	4.5-5.0	Black	16-24 × 9-13
<i>M. deliciosa</i>	Edible	3	2.0-7.5	1.5-5.0	Pale	7-13 × 15-23
<i>M. semilibera</i>	Edible	7	1.0-2.5	7.0-10.0	Yellow	9-11 × 13-17

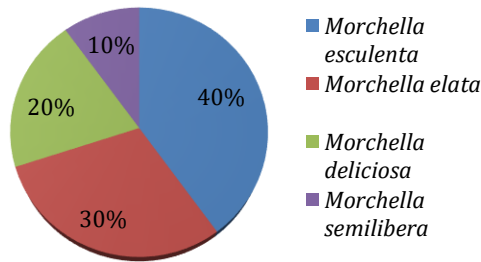


Figure 2: Distribution of four species of morels in Poonch District of Azad Jammu and Kashmir.

4.5-5.0 cm. Microscopic features were also examined where spore size was measured $16-24 \times 9-13 \mu\text{m}$ (Table 1).

***Morchella deliciosa* (Delicious morels):** It was found in suburban habitats under fruit trees and in old orchards (Fig. 3c). The cap has vertically elongated ridges. Spore print was of pale in color (Fig. 3c). Macroscopic features such as pileus diameter ranged 2-7.5 cm and stipe length ranged 1.5-5.0 cm. The stipe was 2/3 of pileus and appeared as white colored. Microscopic characteristics were also examined where spore size measured was $7-13 \times 15-23 \mu\text{m}$ (Table 1).

***Morchella semilibera* (Half-free morels):** *M. semilibera* is also known as half free morel. It was found in the studied area under hard woods, sandy areas, grasses, trees, disturbed gardens during start of spring season at a temperature around 7°C . Spore print was yellow in color (Fig. 3d). Morphological characterization was conducted where diameter of pileus and length of stipe were found 1.0-2.5 cm and 7.0-10.0 cm, respectively. Further, spore size ranged between $9-11 \times 13-17 \mu\text{m}$ (Table 1).

DISCUSSION

Poonch district of Azad Jammu and Kashmir, being part of Himalayas region is known for its cold temperate climate and abundance of forest cover. Therefore, the district qualifies to be an ideal candidate for the presence of morels. Morels are considered as lavished diet due to scarcity, unique texture, aroma, and health benefits. However, to our knowledge, no systematic study has been conducted in the recent past on the presence of morels in the study area. Contrarily, there are reports on the presence of morels (mushrooms) from different parts of Himalayas and Hindu-Kush mountain region (Hamayun et al., 2006; Kumar and Sharma, 2011). Morels were regularly also reported from other parts of Pakistan and different other countries such as Turkey, India, China, North America etc. (Pilz et al., 2007).

In the current study, four species of edible morels (*M. esculenta*, *M. elata*, *M. deliciosa* and *M. semilibera*) were collected from Poonch area of Azad Jammu and Kashmir. Since centuries members of *Morchella* genus were used as food as well as part of the local healing system. Among four morel species, the most commonly found morel was *M. esculenta*. The results of study are similar to findings of Prasad et al. (2002), who also mentioned abundance of *M. esculenta* from Kumaun Himalaya region (1800

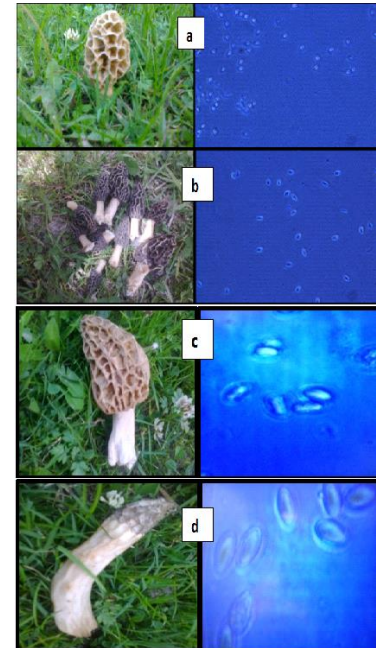


Figure 3: Morels collected from Poonch District of Azad Jammu and Kashmir along with their spore print. a: *M. esculenta*, b: *M. elata*, c: *M. deliciosa* and d: *M. semilibera*.

to 3600 m above sea level) of India. Hamayun et al. (2006) also found these four *Morchella* species in Hindu-Kush mountain region of Swat, Pakistan. *M. esculenta* was predominant species as it contributed 32% of total morels species collected from Swat. Sher et al. (2015) also reported all these four *Morchella* species from Palas valley of Kohistan region of Pakistan. Ajmal et al. (2015) gave a comprehensive account of nutritional and medicinal importance of *M. esculenta*. It is pertinent to mention of *Morchella* spp. especially *M. esculenta* is because Poonch area of Azad Jammu and Kashmir is 2000 m above sea level and has abundance of both conifers and broad leaves trees. *M. elata* which is commonly known as black morel was found second most common morel species during the study and considered as most expensive species of Morchellaceae family which is sold at \$240 per kg in dry form at local markets of Poonch district. It is imperative to mention that other morel species are also prized non-wood products from temperate forests of Poonch area as *M. esculenta*, *M. deliciosa* and *M. semilibera* are sold at \$200, \$180 and \$160 per kg in dry form at local market of Poonch area of Azad Jammu and Kashmir (Laala, 2016).

It is plausible to mention that all *Morchella* spp. were found growing on ground with or without grasses during spring season at a temperature below 10°C . In addition, *Morchella* spp. were found in different types of soils and even more near the burned patches of grasses. The diversity among *Morchella* species is attributed due to complex life cycles, types of nutrition and also ecological interactions with forest habitats. Morels over winter in soil in the form of sclerotium which is a hard, compact structure and germinates once suitable conditions are available during spring. In natural habitat, sclerotium of morels on germination forms fruiting body while on artificial habitat it only germinates into mycelium which is in fact the biggest bottleneck in commercial cultivation of morels worldwide (Ower, 1982; Volk and Leonard 1990; Volk, 1991).

In the present study, morphological features of morels including

pileus diameter and stipe length were also measured; where the minimum pileus diameter measured was about 1.0-2.5 cm in *M. semilibera* and the maximum measurement of pileus diameter was 7.0-7.5 cm in *M. elata*. Similarly, the minimum stipe length was about 1.5-5.0 cm in *M. deliciosa*, and the maximum measurement was observed 7.0-10.0 cm in *M. semilibera*. Similar characteristics of *M. deliciosa* as observed in the present study were described previously by Negi (2006). Further, similar characters of *M. esculenta* as reported here were observed by Sher et al. (2015), while working on morel species of Palas valley. In this study, morels appeared honey combed shaped, conical and somewhat irregular shaped. In stark contrast, the pileus of morels was 7.0-9.0 cm in diameter with conical to spindle shape having vertical ridges and stipe 4.0-5.0 cm long having white to yellow color with a rough surface and were found in burned areas and swampy grounds. There, size differences with same morel species were found in Swat region (Hamayun et al., 2006). Thus, it is clear that morels shape and color is greatly influenced by the local habitat and climate and such minor fluctuations are very common and reported by morel collectors throughout the world.

CONCLUSION

The presence of four morel species in Poonch district of Azad Jammu and Kashmir seems an encouraging sign but it needed to be conserved. Moreover, morels collection and sale could be incorporated in poverty alleviation programs for local communities.

AUTHORS' CONTRIBUTIONS

M.U. Raja and S.R.H. Gardezi conceived and designed the experiments; G. Laala performed the experiments; G. Laala, M.U. Raja and G. Irshad analyzed the data; M.U. Raja, S.R.H. Gardezi, G. Irshad and A. Akram contributed materials/ analysis/ tools, and M.U. Raja and G. Laala wrote the manuscript.

REFERENCES

Ajmal, M., Akram, A., Ara, A., Akhund, S. and Nayyar, B.G. 2015. *Morchella esculenta*: An edible and health beneficial mushroom. *Pakistan Journal of Food Sciences*, 25(2): 71-78.

Alexopoulos, C.J., Mims, C.W. and Blackwell, M.M. 1996. *Introductory Mycology*, 4th Edition. John Wiley & Sons, Inc., pp. 880.

Arora, D. 1986. *Mushrooms Demystified: A Comprehensive Guide to the Fleshy Fungi*, 2nd Edition. Ten Speed Press, Berkeley, California, USA, pp. 976.

Boa, E. 2004. *Wild Edible Fungi: A Global Overview of their Use and Importance to People*. Non-wood Forest Product Series No. 17. Food and Agriculture Organization of the United Nations, Rome, Italy, pp. 147.

Christensen, M. and Larsen, H.O. 2005. How can collection of wild edible fungi contribute to livelihoods in rural areas of Nepal? *Journal of Forest and Livelihood*, 4(2): 50-55.

Ciesla, W.M. 2002. *Non-wood Forest Products from Temperate Broad-Leaved Trees*. Non-wood Forest Product Series No. 15. Food and Agriculture Organization of the United Nations, Rome, Italy, pp. 125.

Du, X.H., Zhao, Q. and Yang, Z.L. 2015. A review on research advances, issues, and perspectives of morels. *Mycology*, 6(2): 78-85.

Hamayun, M., Khan, S.A., Ahmad, H., Shin, D.H. and Lee. I.J. 2006. Morel collection and marketing: A case study from the Hindu-Kush mountain region of Swat, Pakistan. *Lyonia*, 11(2): 7-13.

Khan, M.A., Khan, M.A., Hussain, M. and Mujtaba, G. 2010. An ethnobotanical inventory of Himalayan region Poonch Valley Azad Kashmir (Pakistan). *Ethnobotany Research and Applications*, 8: 107-124.

Kumar, S. and Sharma, Y.P. 2011. Diversity of wild mushrooms from Jammu and Kashmir (India). *Proceeding of 7th International Conference on Mushroom Biology and Mushroom Products (ICMBMP7)*, October 4-7, 2011. World Society for Mushroom Biology and Mushroom Products and INRA, Arcachon, France.

Kuo, M. 2001. Making spore prints. Retrieved from <http://www.mushroomexpert.com/studying.html>.

Kuo, M., Dewsbury, D.R., O'Donnell, K., Carter, M.C., Rehner, S.A., Moore, J.D., Moncalvo, J.M., Canfield, S.A., Stephenson, S.L., Methven, A.S. and Volk, T.J. 2012. Taxonomic revision of true morels (*Morchella*) in Canada and the United States. *Mycologia*, 104(5): 1159-1117.

Laala, G., Raja, M.U., Gardezi, S.R.A., Irshad, G., Akram, A. and 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.

Laala, G. 2016. *Morphological characteristics of mushrooms in Poonch Area (Azad Kashmir)*. M.Phil thesis. Department of Plant Pathology. Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan.

Lakhanpal, T.N., Shad, O. and Rana, M. 2010. *Biology of Indian Morels*. I.K. International Publishing House, New Delhi, India, pp. 245.

Latif, A., Shinwari, Z.K. and Begum, S. 2003. Potential and market status of mushrooms as non-timber forest products in Pakistan. *Ethnobotanical Leaflets*, 2003(1): 10.

Masaphy, S. 2010. *Biotechnology of morel mushrooms: successful fruiting body formation and development in a soilless system*. *Biotechnology Letters*, 32: 1523-1527.

Negi, C.S. 2006. Morels (*Morchella spp.*) in Kumaun Himalaya. *Natural Product Radiance*, 5(4): 306-310.

O'Donnell, K., Rooney, A.P., Mills, G.L., Kuo, M., Weber, N.S. and Rehner, S.A. 2011. Phylogeny and historical biogeography of true morels (*Morchella*) reveals an early Cretaceous origin and high continental endemism and provincialism in the Holarctic. *Fungal Genetics and Biology*, 48(3): 252-265.

Ower, R. 1982. Notes on the development of the morel ascocarp: *Morchella esculenta*. *Mycologia*, 74(1): 142-144.

Pilz, D., McLain, R., Alexander, S., Villarreal-Ruiz, L., Berch, S., Wurtz, T.L., Parks, C.G., McFarlane, E., Baker, B., Molina, R. and Smith, J.E. 2007. Ecology and management of morels harvested from the forests of western North America. *Gen. Tech. Rep. PNW-GTR-710*. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR, pp. 161.

Prasad, P., Chauhan, K., Kandari, L.S., Maikhuri, R.K., Purohit, A., Bhatt, R.P. and Rao, K.S. 2002. *Morchella esculenta* (Guchhi): Need for scientific intervention for its cultivation in Central Himalaya. *Current Science*, 82(9): 1098-1100.

Sabra, A. and Walter, S. 2001. *Non-wood forest products in the Near East: A regional and national overview*. Working paper FOPW/01/2. Non-wood Forest Products Programme, Forest Products Division, Forestry Department, Food and Agriculture Organization of the United Nations, Rome, Italy, pp. 120.

Sher, H., Aldosari, A. and Bussmann, R.W. 2015. Morels of Palas valley, Pakistan: A potential source for generating income and improving livelihoods of mountain communities. *Economic Botany*, 69(4): 345-359.

Tietel, Z. and Masaphy, S. 2018. True morels (*Morchella*) - nutritional and phytochemical composition, health benefits and flavor: A review. *Critical Reviews in Food Science and Nutrition*, 58(11): 1888-1901.

Volk, T.J. 1991. Understanding the morel life cycle: key to cultivation. *McIlvainea*, 10(1): 76-81.

Volk, T.J. and Leonard, T.J. 1990. Cytology of the life cycle of *Morchella*. *Mycological Research*, 94(3): 399-406.

Zachos, F.E. and Habel, J.C. (eds.). 2011. *Biodiversity Hotspots - Distribution and Protection of Conservation Priority Areas*. Springer-Verlag, Berlin, pp. 546.