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Department of Botany,
University of Calcutta,
Kolkata 700 019, India

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A Checklist of Ascomycetous mushrooms from North Kashmir, India

MEHRAJUDDIN TALIE[1,2], ASIF HAMID DAR[1], SHOAIB AHMAD LONE[1], JOHN MOHD WAR[1]*, ABDUL HAMID WANI[1], MOHD YAQUB BHAT[1]

[1]Section of Mycology and Plant Pathology, Department of Botany, University of Kashmir, Srinagar-190006, Jammu and Kashmir

[2]Department of Botany, Government Degree College Sumbal-193501,Jammu and Kashmir

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The Kashmir region in India harbours rich macrofungal diversity, however meager work has been carried out to explore the diversity of Ascomycetous mushrooms till date. This study aimed to explore the diversity of Ascomycetous mushrooms from north Kashmir using modern phylogenetic tools supported by classical phenetic approaches, and producing a checklist along with their collection sites, valid photographs, edibility status and key taxonomic characteristics. Periodical field surveys and collections were carried out in sixteen (16) sampling sites belonging to district Kupwara, Baramulla and Bandipora of north Kashmir during 2018-2021. A total of twenty-four (24) wild Ascomycetous mushrooms were documented from the study area belonging to two (02) orders, seven (07) families and ten (10) genera. The family Morchellaceae was dominant with nine (09) species followed by Helvellaceae (5 spp.), Discinaceae (4 spp.), Pyronemataceae and Pezizaceae (2 spp. each), Sarcoscyphaceae and Xylariaceae (1 sp. each). Majority of the Ascomycetous mushrooms documented in this paper were collected from the areas of district Kupwara. The present study also revealed four species viz. *Morchella vulgaris, M. quercus, M. kaibabensis* and *Verpa conica* to be new records and new additions to the mycoflora of Kashmir as well as Indian mushroom flora. Various attributes provided in this checklist widen the understanding on genetic diversity, distribution, edibility status, and vernacular names of wild Ascomycetous mushrooms from north Kashmir and will be used as a reference database to help in future research work in different fields.

Keywords: Ascomycetous mushrooms, checklist, edibility, North Kashmir

INTRODUCTION

Fungi play a pivotal role in litter degradation, developing forest ecosystems and establishment of plants in forests (Kjoller and Struwe, 1982; Muthukrishnan *et al.,* 2012; Tapwal *et al.,* 2013).The fungal kingdom is six times larger than the plant kingdom, according to estimates. At present, the estimated number of fungi on earth ranges between 1.5 to 12 million species, out of which only 140,000 to 150,000 species have been described and 41,000 are known to be macrofungi (Hawksworth and Lucking, 2017; Malik *et al.,* 2018; Bhunjun *et al.,* 2022).

The phylum Ascomycota (Ascomycetes), commonly called as cup fungi or sac fungi is by far the major group of fungi, estimated to include 2700 genera and 64000 species (Kirk *et al.* 2008). They include diverse group of fungi that varies in their micro-morphology, ontogeny, ultrastructure, ascocarp features, ascus architecture, ascospore nature, and other traits, as well as their ability to grow in a variety of environments. These comprise morels, truffles, cup fungi, dead man's fingers, saddle fungi, king Alfred's cakes, brewer's and baker's yeast, powdery mildews, and caterpillar fungi (Kuo *et al*. 2012).

Jammu and Kashmir, located between 32°17' and 37°03' North latitudes and 72°03' and 80°20' East longitudes, with a total land area of 222,235 km2 and an annual rainfall of 60 to 80 cm. It is bounded to the northern and eastern sides by the core Himalayan peaks, and to the southern end by the Punjab plains. Due to its varied climatic conditions, Jammu and Kashmir provide a perfect location and ideal site for mushroom

*Correspondence:johnbotanyku@gmail.com

collection. But exploration and documentation of the mycoflora of Kashmir is still in its infancy and there are countless mushroom species to be collected and reported (Talie *et al.* 2021). Only 286 mushroom species have been described from Jammu & Kashmir, with 196 species reported from Kashmir so far, and only a few of the species reported from Kashmir belong to the Ascomycetes (Dar *et al* 2009, 2010; Pala *et al.*2012; Wani *et al.*2010, 2015, 2020; Talie *et al.*2020, 2021; War *et al.,* 2023). There is an incredible scope for exploring Northern belt of Kashmir for mushroom diversity, because the research involved in literature revealed that only few Ascomycetous mushrooms have been reported from North Kashmir due to its far-flung, difficult and disturbed conditions. So, the main purpose of the present research was to collect and identify the diversity of wild Ascomycetous mushrooms growing in different parts of North Kashmir to prepare a checklist along with their diagnostic features, vernacular names, collection sites, and edibility status, so as to generate awareness among the general public regarding their importance and usage for the benefit of mankind.

MATERIALS AND METHODS

Mushroom Sampling

Periodical field trips were designed to sixteen sampling sites of North Kashmir, viz., Lolab Valley, Handwara, Wadpora, Bungus Valley, Gulmarg, Tangmarg, Drung, Pattan, Warpora, NaidKhai, Pazalpora, Main Bandipora, Wular Lake, Malangam, Bankoot and Zalwan Bandipora (Fig. 1) according to the standard protocols and methods of Atri *et al.* (2005), Loizides *et al.* (2016) and Dorjey *et al.* (2019). Besides, the field notes and valuable information about the mushrooms growing in the surveyed areas and their local names, edibility, locations, etc. were recorded.

Taxonomic identification

The Ascocarps were photographed from the study sites using Nikon DSLR, D-500 and 24-megapixel camera and carefully dugout with the help of a knife and placed in collection bags. Various morphological characters such as shape, size, colour, and dimensions of fruiting bodies, which helped in identification of collected Ascomycetous macrofungi were noted under natural conditions before preservation. Likewise, the diverse microscopic characteristics were investigated from rehydrated slices of sporocarps mounted in 3% KOH and stained with cotton blue or Melzer's reagent. These sections were examined under trinocular microscope. The observations of micro as well as macroscopic characteristics were accomplished according to the procedures of Waraitch (1976), Kanwal *et al.* (2010) and Loizides *et al.* (2016).

Final identification

The collected Ascomycetous mushrooms after proper micro-morphological investigations were finally identified by consulting different field guides, relevant literature and referring the recent monographs (Wani *et al.* 2010; Kanwal *et al.* 2010; Richard *et al.* 2014; Du *et al.* 2015; Dorjey *et al.* 2019). The authenticity of some selected Ascomycetous mushrooms showing ambiguity in identification were also confirmed by molecular characterization using analysis of ITS sequences (White *et al.*1990). Furthermore, Websites like www.mycokey.com, www.mushroomobserver, and www.mushroomexpert.com were also used for identification and related information. All the identified specimens were submitted to the KASH, Herbarium of the Department of Botany, University of Kashmir, Srinagar, for their respective accession numbers.

Cord and two-way cluster analysis

Cord and cluster analysis were done to reveal linkage or relationships and similarities between two entities. To compute the Euclidian's two-way cluster analysis the software PAST (Version 4.03) was used. Furthermore, Origin (version 2021b) software was used to prepare chord diagram.

RESULTS

Classical taxonomy of Ascomycetous mushrooms

In the present study, micro-morphological and other related details of all the collected

Table 1: List of wild Ascomycetous mushrooms from North Kashmir, India with their families, genera, and sites of collection

Family	Genus	Species with Author citation	Collection site
Morchellaceae	*Morchella*	1. *M. esculenta* (L.) Pers.	Pattan, Tangmarg, Handwara, Bandipora
		2. *M. crassipes* (Vent.) Pers.	Gulmarg, NaidKhai, Handwara.
		3. *M. vulgaris* (Pers.) Gray	Gulmarg, Wadpora, Zalwan Bandipora
		4. *M. elata* Fr.	Gulmarg, Wadpora, Handwara
		5. *M. kaibabensis* Beuj, T. A. Clem. and T. J. Baroni	Gulmarg, Handwara, Drung
		6. *M. quercus - ilicis* Clowez. and L. Ramero	Handwara, Tangmarg
	Verpa	1. *V. bohemica* (Krombh.) Schrot.	Handwara, Gulmarg, Zalwan Bandipora.
		2. *V. conica* (O. F. Mull.) Sw.	Handwara, Gulmarg, Wadpora Kupwara
	Disciotis	1. *D. venosa* (Pers.) Boud.	Gulmarg, Handwara
Helvellaceae	*Helvella*	1. *H. acetabulum* (L.) Quel.	Handwara, Gulmarg, Zalwan Bandipora .
		2. *H. leucopus* Pers.	Gulmarg, NaidKhai, Bungus valley,
		3. *H. queletii* Bres.	Wadpora, Handwara, Pattan, NaidKhai
		4. *H. lacunosa* Afzel.	Gulmarg, Zalwan Bandipora.
		5. *H. crispa* (Scop.) Fr.	Bungus Valley, Lolab Valley, Gulmarg, NaidKhai Bandipora
Discinaceae	*Gyromitra*	1. *G.* species	Tangmarg, Pazalpora Bandipora, Handwara
		2. *G. sphaerospora* (Peck) Sacc.	Gulmarg, Drung, Zalwan Bandipora
		3. *G. gigas* (Krombh.) Cooke	Gulmarg, Wular lake, Handwara, Kupwara
		4. *G. perlata* (Fr.) Harmaja	Gulmarg, Tangmarg, Wadpora Kupwara
	Scutellinia	1. *S. scutellata* (L.) Lamb.	NaidKhai, Gulmarg, Wadpora
Pyronemataceae	*Geopora*	1. *G. sumneriana* (Cooke) M. Torre	Handwara, Kupwara, Wular lake, NaidKhai, Gulmarg
Pezizaceae	*Peziza*	1. *P. repanda* Pers.	Handwara, NaidKhai, Kupwara, Gulmarg
		2. *P. badia* Pers.	NaidKhai, Gulmarg, Tangmarg, Lolab Valley
Sarcoscyphaceae	*Sarcoscypha*	1. *S. coccinea* (Scop.) Lambotte	Handwara, Gulmarg, Wadpora Kupwara
Xylariaceae	*Daldinia*	1.*D. concentric* (Bolton) Ces. and De Not.	Handwara, Kupwara, Tangmarg

Table 2: A checklist of wild Ascomycetous mushrooms documented from North Kashmir, India along with their scientific names, local names, accession numbers, habit and habitat and diagnostic features.

Scientific name	Local name	Accession number	Habit and habitat	Diagnostic features
Helvella Acetabulum (L.) Quel.	Brearhaend	4197-KASH Herbarium	Scattered, mycorrhizal (symbiotic) relationships with *Populus* plants.	Pileus: 3.0 -3.8 cm in dimensions, saucer or cup - shaped, grey -brown; Stipe: stout, white, wider at the tip and narrower at the foot; Ascospores: 12.8 - 16.8 × 11.2 -13.6 µm, subglobose to oval, glittery white, and smooth; Asci: Elongate, cylindrical, thin-walled, translucent, and contain eight ascospores.
Helvella leucopus Pers.	Kannaguech, Kanpapri	4198-KASH Herbarium	Probably showing mycorrhizal relationships with *Populus* plants or trees.	Pileus: Chocolate or brown -black in colour, curled or folde d, with 2 to 4 distinct asymmetrical lobes; Stipe: Dull white to creamish, clean or smooth, empty, and wider at the bottom, occasionally somewhat furrowed below; Ascospores: Elliptical, translucent, thin walled, 20 -24 × 13-15 µm, homogeneous, with a big ce ntral lipid droplet encircled by smaller ones; Asci: Cylindrical and 8 - spored.
Helvella Queletii Bres.	Kannaguech	4199-KASH Herbarium	Possibly symbiotic, found alone or in groups of two to three under conifers.	Pileus: Saucer shaped, interior brown and ex terior cream colored, 4.5 -5.0 cm wide; Stipe: Short and measuring about 2.0-2.5 cm in length; Ascospores: Oblong to subglobose, 10.0 -16.0 × 8.0 -12.0 µm, glossy white, and thin walled; Asci: Elongate, tubular, 8-ascospores per ascus.

Helvella Lacunose Afzel.	Shajikunal, Bujjekanguch or Kanpapri	4200-KASH Herbarium	Undoubtedly mycorrhizal, grows singly, beneath deciduous trees.	Pileus: A pothecia scattered, disc reflexed and irregularly lobed, 0.5 -2 cm wide, dark brown; receptacle white to yellowish brown; St ipe: 0.7 -2 cm high and 0.3 -0.5 cm wide, grey brown, lacunose; Ascospores: broadly ellipsoid, 15 -17 × 11-12 µm, smooth; Asci: 8 -spored, cylindrical and tapering to base.
Helvella crispa (Scop.) Fr.	Batta haend	4201-KASH Herbarium	Possibly symbiotic (mycorrhizal), grows singly on rotting woods.	Pileus: Saddle shapedmeasuring about 1 -5 cm, surface is smooth and bald or slightly wrinkled; Stipe: white or slightly pinkish in colour,deeply and ornately ribbed, cross -veins and pockets are also present; Ascospor es: smooth, elliptical with one large oil droplet at center, the size of each ascospores is 16-21 × 10-14 µm; Asci: Each ascus contains eight ascospores.
Gyromitra species	Not available	4323-KASH Herbarium	Undoubtedly symbiotic, occurring alone, under hardwoods or conifers.	Pileus: Cup shaped, measuring about 4 -5.5 cm in diameter, white to creamish in color outside and light brown inside, inverted with groves at margins at initial stage but opens up at maturity; Stipe: Very short, white to creamish in color, smooth, without ridges and groves; Ascospores: Oval shaped, measuring about 10.0 -15.0 × 7.0 -11.0 µm, d ouble layered with 2 -3 oil droplets; Asci: cylindrical, tapering to base, thin-walled and 8-spored.
Gyromitra sphaerospora (Peck) Sacc.	BujiKankech	4324-KASH Herbarium	Saprobic, isolated, dispersed, or luxuriantly growing on rotting hardwoods.	Pileus: 4 -12 cm across, 2 -8 cm high, weakly convex, medium to dark brown, under surface creamy to brown, coarsely granular, ridged; Stipe: 2-10 cm high, whitish above, rosy to purple red beneath, extensively and unevenly fluted with edgy ribs; Ascospores: 8.0 -13 µm in diameter, globose and smooth developing a large black bubble at maturity; Asci: Eight spored and cylindrical.
Gyromitra gigas (Krombh.) Cooke	BujiKankech, Kannaguech	4325-KASH Herbarium	Saprobic, grows under coniferous trees particularly under shade.	Pileus: 2 -8 cm in height and 2 -4 cm in width, gentlywrinkled, moderately lobed, occasionally resembling a “dog's” mouth,under -surface white, hairless or bald; Stipe: Light brown to whitish, 2 -4 cm tall and 2 -3 cm wide, occasionally with thick ribs, linked t o the cap in the middle; Ascospores: 20-24 × 11.5-12µm, slightly roughened and fusiform with two knob -like apiculi at either end ; Asci: 8-spored.
Gyromitra perlata (Fr.) Harmaja	Pappadkanpa pri	4326-KASH Herbarium	Saprotrophic, typically found in coniferou s environments on humus or decaying wood.	Pileus: Cup or ear -shaped, brown to tan -brown, wrinkled, disc -like creamish outside and brown to dark brown inside, the cup measures 4 -10 cm across; Stipe: When present, is 0.5 -1.0 cm thick and strong, with a dark -brown colour; Ascospores: Spindle-shaped ascospores with one prominent oil droplet, measuring 25.5-41.5 × 10.5-15 µm ; Asci: Long and cylindrical, each ascus with 8 - ascospores.
Sarcoscypha coccinea (Scop.) Lambotte	Wazelshajika n, Lal bhuti or Lal childi	4327-KASH Herbarium	Saprobic on decaying hardwood sticks sometimes on buried wood, found to grow magnificently or in clusters.	Pileus: Saucer shaped, measuring about 3.0 -5.5 cm in dimeter, inner surface is scarlet red, and fading with age to orangish while as outer sterile surface is mostly whitish or creamish in color; Stipe: When present is rudimentary, and continuous with the under surface; Ascospores: Smooth, translucent and elliptical with many oil droplets, showing dimensions of 24 -37.5 × 10-11.5 µm; Asci: Cylindrical, long, and eight spored.
Scutellinia scutellata(L.) Lamb.	Not available	4341-KASH Herbarium	Saprobic on rotted wood or on damp soil growing in clusters.	Ascocarp: Shallow disc shaped to broadly cup shaped, 0.3 -1.5 cm in diameter, inner f ertile surface is scarlet red to bright orange, and smooth. However, outer sterile surfaceis brownish or pale orange in colour, covered with tiny dark hairs measuring about 0.5 -1.0 cm in length; Stipe: Absent (sessile); Ascospores: 17 -23 × 10.5-14 µm in di ameter, elliptical, translucent, smooth when immature but at maturity showing rough exterior

Geoporasumneriana (Cooke) M. Torre	Kanpapp-ar or Shajikann	4328-KASH Herbarium	Found in tiny groups on dry or moist ground beneath cedar trees or other prominent mostly*Populus* species	Ascocarp: Cup-shaped, with a smooth inner fertile surface that ranges in colour from pale cream to yellowish grey. When completely open, the ascocarps are 3-5 cm tall and 5-7 cm broad. The exterior unproductive surface is coated with tiny, curly brown hairs, and ranges in coloration between orange-brown to reddish-brown; Stipe: Absent; Ascospores: Ellipsoidal to fusiform, smooth, 27-37 × 13-16 µm; each usually containing two large oil drops; Asci: Eight-spored, measuring about 370 × 19 µm.
Peziza repanda Pers.	Batikucch	4329-KASH Herbarium	Saprobic on well-rotted woods, mostly hardwoods but also woody biomass or sandy soil rich in rotting wood, found in clusters.	Ascocarp: At initial stages, light brown to white, saucer-shaped, with a small stem-like protrusion on the external surface and a finely fuzzy under surface. But, squished or twisted backwards at maturity, 6-12 cm across, the margin frequently fractures; Stipe: Absent;Ascospores: Elliptic, smooth, lacking oil droplets, measuring 11-16 × 6-10 µm in dimensions; Asci: Cylindrical, 8-spored, and hyaline.
Peziza badia Pers.	Not available	4330-KASH Herbarium	Saprobic on well-decayed logs, or on the soil rich with humus or chips, growing singly or in clusters.	Ascocarp: Cup-shaped when young but at maturity it become inverted hemispherical with dimensions of 2.0-7.5 cm across and is 0.1-3.5 cm high; Stipe: Absent, hence sessile; Ascospores: Elliptical, thick walled, hyaline having dimensions of 15.5-19.5 × 8.0-12 µm; Asci: Eight-spored, cylindrical, translucent and measuring up to 250-300 × 14-15 µm.
Daldinia concentrica (Bolton) Ces. and De Not.	Naartate	4331-KASH Herbarium	Saprobic on dead or dying hardwoods, growing singly or in clusters.	Ascocarp: 2 to 8 cm in diameter, ball-shaped, with multiple growth rings, originally brownish and compact, then dry up or become less dense; New Perithecia develops every season with outer fertile layer, inside which the next season's ascospores are produced. Stipe: Absent; Ascospores: Ellipsoidal to fusiform, smooth and measuring about 12-17 × 6-9 µm in size.
Disciotis venosa (Pers.) Boud.	Kanpapri	4332-KASH Herbarium	Saprobic, grows alone or in clusters on ground, under coniferous trees.	Ascocarp: 3.0-18.0 cm in diameter, initially cup-shaped with inward curled margins, but with age became flattened and attain irregular saucer-shape, upper surface yellowish tan to roseate brown, initially bald or smooth but, latter on develop prominent vein-like wrinkles at the center; Stipe: Thick, short, usually hidden in the soil; Ascospores: Ellipsoidal, smooth, inamyloid, without oil droplets and measuring about 21-24 µm × 11-15 µm; Asci: Cylindrical and eight-spored.
Morchella esculenta (L.) Pers.	Gucchi or Batta guech or Khazerkanng uech	4333-KASH Herbarium	Saprotrophic or mycorrhizal found in forests, orchards, disturbed grounds and burnt areas. They occur singly or in groups of 3-7 members.	Pileus: Pale brownish to greyish brown, ridges' borders are typically not darker than that of the pits, and the shape is oval, rarely coneshaped with a rounded top or more prolonged. Pileus is empty, with a bottom edge linked to the stipe, and measures 2-7 cm wide and 2-10 cm high; Stipe: White to light yellow, empty, upright, bulbous base, generally about 2-9 cm long; Ascospores: Ellipsoidal, smooth and translucent, measuring about 16.5-21.0 µm× 8.0-11.0 µm;Asci: Eight spored, cylindrical and translucent.
Morchella crassipes (Vent.) Pers.	Kan guech or Gucchi	4334-KASH Herbarium	Saprotrophic, found in coniferous forests, orchards and grow scattered or in small	Pileus: Yellow to brownish yellow, sub-globose to elongate, rarely conical, honey comb like measuring about 5.5-8.5 cm across and 6-14 cm tall, comprise irregularly fertile pits separated by narrow ridges, unlike *Morchella esculenta* ridges are very thin; Stipe: Smooth, hollow, tapering towards the apex with bulbous base, white to pale

			groups of 3 -5 fruiting bodies.	creamish; Ascospores: Elliptical, smooth, translucent, without oil droplets, measuring about 17.5-22.0 µm× 10.0-13.0 µm; Asci: Eight -spored, cylindrical and translucent.
Morchella vulgaris (Pers.) Gray	Gucchi, guech or Khazerkanng uech	4335-KASH Herbarium	Found in coniferous forests, orchards and grow singly or in small groups.	Pileus: Predominantly greyish in colour, unlike, *Morchella esculenta* the ridges and grooves are extremely irregular and brightly colored, elongate to somewhat conical, measuring about 4.5 -6.0 cm across and 6.5-9.0 cm tall; Stipe: Smooth, hollow internally like cap, base is slightly enlarged and grooved, with creamish dust -like particles on surface, white to creamish; Ascospores: Ellipsoidal, smooth, hyaline, without oil droplets, measuring about 18.5 - 25.0 µm× 9.0-12.5 µm; Asci: Eight - spored, cylindrical, broad, and translucent.
Morchella elata Fr.	Dum guech, Kan guech	4336-KASH Herbarium	Grow individually or in clusters on the ground, usually near conifer trees.	Pileus: 3.5 -8 cm in diameter and 5 -7.5 c m tall, hollow and egg -shaped inside with distinctive honey comb surface comprising of dark or tan, black ridges, and shady brown pits, blackening with maturity; Stipe: Smooth at the top and grooved at base, white and hollow, measuring about 1.0 - 2.5×4-9cm; Ascospores: Smooth, with polar oil droplet, elliptical and translucent with dimensions of 17 -24 µm× 10.5-14 µm; Asci: Cylindrical and eight spored.
Morchella kaibabensis Beug, T. A. Clem. and T. J. Baroni	Guech, kannguech	4337-KASH Herbarium	Grow usually singly but not in clusters unlike other morels on the ground, usually near Pine trees.	Pileus: Conical to somewhat spherical, 30 -40cm tall and 2 -5cm wide, ridges are grey and become black at maturity, pits are vertically elongated with depression of about 0.6cm. Cap has free edges and show distant attachment than other true morels; Stipe:Cylindrical to clavate showing depressions at the base, white to creamish white with rough surface; Ascospores: Elliptical, smooth and translucent, 20 -25 µm × 12-17µm; Asc i: Cylindrical, translucent, eight -spored and thin walled.
Morchella quercus-ilicis f. *Kakiicolor* Clowez and L. Romero	Kannguech	4338-KASH Herbarium	Grow separately or in groups on the soil, usually near conifer (Pine) trees.	Pileus: Conical to sub spher ical, 4-6cm tall and 2 - 4cm wide, light black to greyish black and later changes to pinkish brown, longitudinal ridges are dense and more or less parallel having same colour like pits but gradually become rusty -brown while as transverse ridges are abundant, narrow and forming an irregular ladder -like pattern. Pits are shallow and somewhat deep; Stipe: Whitish or creamish, usually enlarged at the base with ridges on either side, hollow, soft; Ascospores: Ellipsoidal, smooth, thin-walled and measuring about 13-17.5 µm ? 7.5 -10 µm. Asci: Cylindrical, curved and eight-spored.
Verpa bohemica (Krombh.) Schrot.	Paankat or Fosse	4339-KASH Herbarium	Probably mycorrhizal, found under hardwoods, usually grow singly.	Pileus: 1-4 cm across, nearly conical or irregular to bell shaped, wrinkled longitudinally, brown to dark yellow brown with whitish under surface; Stipe: 6 - 18 cm long and 1 -3 cm thick, sometimes tapered upwards or downwards, creamy white; Ascospores: Smooth, elongated, elliptical, thick walled and measuring about 47-80 µm × 13-22 µm; Asci: Two-spored only, small in size
Verpa conica (O. F. Mull.) Sw.	Fosse	4340-KASH Herbarium	Possibly mycorrhizal, found under hardwoods and conifers, mostly grow singly.	Pileus: Smooth, c ap swings free from the stalk, somewhat like a minute brown cover or thimble on the termination of a stalk, cap is convex thimble shaped or bell -shaped measuring about 1.5 -4 cm across and 2-4 cm high, tan to dark brown in color, smooth or somewhat wrinkled at maturity; Stipe: Creamy white to ye llowish, measuring about, 4 -12 cm long and 0.5 -2 cm thick, more or less equal tappers upward and base is slightly thicker, surface of stipe is smooth or rather fuzzy; Ascospores: Ellipsoid, smooth, hyaline in KOH with dimensions of 26-32 µm × 14-18 µm. Asc i: Tubular or cylindric, instead of two, each ascus contain eight ascospores.

Table 3: ITS Sequences of *Morchella* and *Verpa* submitted to NCBI along with GenBank accession numbers, sequence ID, release date and names of species

Accession No.	Sequence	Release Date	Name
MW479971	SR1765-AN-CAITSR_C02.ab1	Jan 20, 2021	*Morchella Kaibabensis*
MW479972	SR1765-M2-CAITSR_E01.ab1	Jan 20, 2021	*Morchella quercus*
MW479973	SR1664-MW1-CAITSR_B08.ab1	Jan 20, 2021	*Morchella quercus*
OL504954	SR1779-M13-CAITSR_C14.ab1	Nov 22, 2021	*Morchella elata*
OL654279	SR1791-MA15-CAITSR_D02.ab1	Dec 01, 2021	*Morchella crassipes*
OL504953	SR1778-M15-CAITSR_C13.ab1	Nov 22, 2021	*Morchella crassipes*
OL504956	SR1781-M5-CAITSR_E16.ab1	Nov 22, 2021	*Morchella esculenta*
OL654278	SR1790-MA5-CAITSR_E01.ab1	Dec 01, 2021	*Morchella esculenta*
OMO49833	SR1792-M6-CAITSR_E02.ab1	Jan 03, 2022	*Morchella vulgaris*
OK413347	SR1777-M13-CAITSR_E13.ab1	Oct 12, 2021	*Verpabohe mica*
OL504955	SR1780-M11-CAITSR_C15.ab1	Nov 22, 2021	*Verpa conica*

Ascomycetous mushrooms were recorded. Considerable variations regarding shape, color, and size of ascocarps, ascospores, pileus, and stipe were observed in diverse species of Ascomycetous mushrooms. The detailed description of Ascomycetous mushrooms collected and identified from surveyed areas of North Kashmir during the present research are presented in the Tables (1, 2) and Figs.(2-6)

Identification of some important mushrooms based on Molecular characterization

In the present study, two important genera of Ascomycetous mushrooms, Morchella and Verpa were also identified based on molecular characterization in order to remove the ambiguity observed in their identification based on morphological and other characteristics. Eleven ascocarps/fruiting bodies belonging to *Morchella* and *Verpa* species (M1, MA1, M2, MA2, M3, M4, M5, MA5, M6, MV1, MV2) were analysed at molecular level using various molecular tools and techniques to further confirm their identity, and also to analyse genetic variation among these species. Following molecular methods or tools were employed:

Nucleotide BLAST analysis

It was revealed from BLAST results that the sequences of M1 and MA1 presented close likeness (97% and 98%) with M. esculenta. The nucleotide sequences of M2 and MA2 on BLAST analysis exhibited a 100% and 86.12% match to *M. quercus* while as M3 sequences displayed close resemblance (97%-98%) with *M. elata*. Similarly, the sequences of M4 exhibited a 99.44% match to *M. kaibabensis*. Sequence analysis of M5 and MA5 showed a 94% and 95.44% similarity to *M. crassipes*. Similarly, M6 sequences revealed 95.44% similarity with *Morchella vulgaris*. However, the sequences of MV1 and MV2 revealed the similarity of 97.44% and 98% to *Verpa bohemica* and *Verpa conica*, respectively. In order to get GenBank Accession numbers, the *Morchella* and *Verpa* nucleotide sequences in this investigation were deposited to the National Center for Biotechnology Information (NCBI) database (Table 3).

Cord and two-way cluster analysis of Ascomycetous mushrooms

It was revealed from the results of cord analysis (Fig.7) that reported Ascomycetous mushrooms were widely distributed in various sampling sites surveyed during the present study. However, the cord analysis revealed the linkage between reported mushroom samples and surveyed sampling sites. It was also observed from the cord analysis that amongst the sixteen surveyed sites

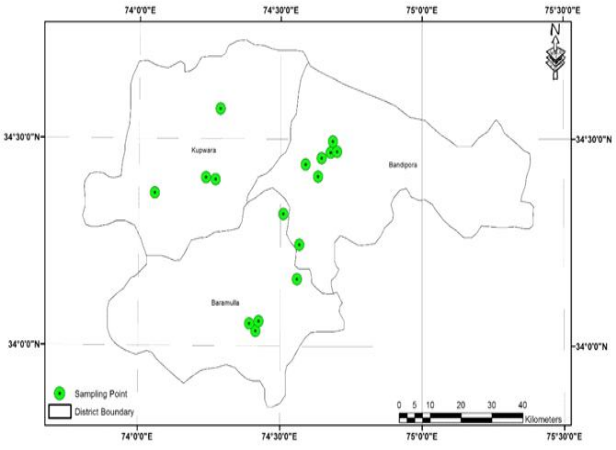

Fig. 1 : Map of North Kashmir showing sixteen sampling sites surveyed during the present study.

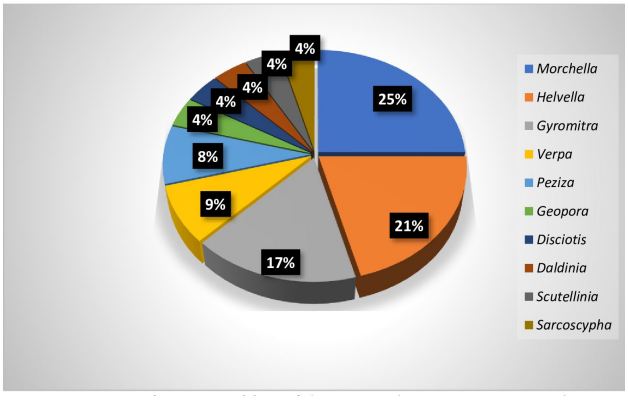

Fig. 2: Genera wise composition of documented Ascomycetous mushrooms

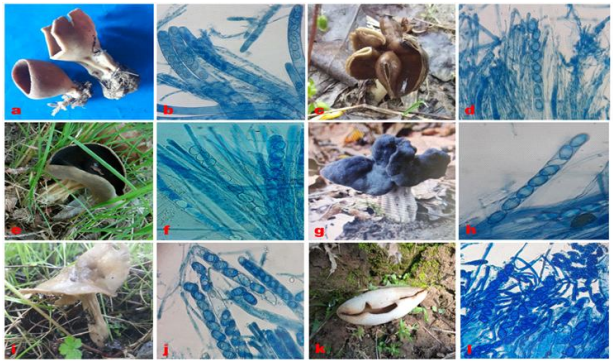

Fig.3.a-l:*Helvella acetabulum:* a. Cup shaped fruiting body with stipe.b. Asci containing eight Ascospores at 400x magnification; ***Helvella leucopus:*** c. Saddle shaped fruiting body with stipe.d. Asci containing eight Ascospores at 400x magnification; ***Helvella queletii:*** e. Saucer shaped fruiting body with stipe.f. Asci containing eight Ascospores at 400x magnification; ***Helvella lacunosa:*** g. Irregularly lobed fruiting body with lacunose stipe. h. Asci containing eight Ascospores at 400x magnification; ***Helvella crispa:*** i. Curled fruiting body with ornately ribbed stipe. j. Asci containing eight Ascospores at 400x magnification; ***Gyromitra* sp.:** k. Cup shaped Ascocarp.l. Asci containing eight oval shaped ascospores.

Fig.4: a-l: *Gyromitra sphaerospora:* a. Ascocarp showing pileus and stipe.b. Asci with eight globose ascospores (400x); ***Gyromitra gigas:*** c. Convoluted Ascocarp showing pileus.d. Asci with eight fusiform ascospores and paraphyses (400x); ***Gyromitra perlata:*** e. Ear shaped fruiting body showing pileus.f. Asci with spindle shaped ascospores (400x); ***Sarcoscypha coccinea:*** g. Saucer shaped Ascocarp.h. Asci with ellipsoidal ascospores (400x); ***Scutellinia scutellata:*** i. Eyelash cup-shaped fruiting body. Fig. j. Asci with eight ascospores (400x); ***Geopora sumneriana:*** k. Fruiting body showing cup shaped pileus.l. Asci with ascospores showing two large oil drops (400x).

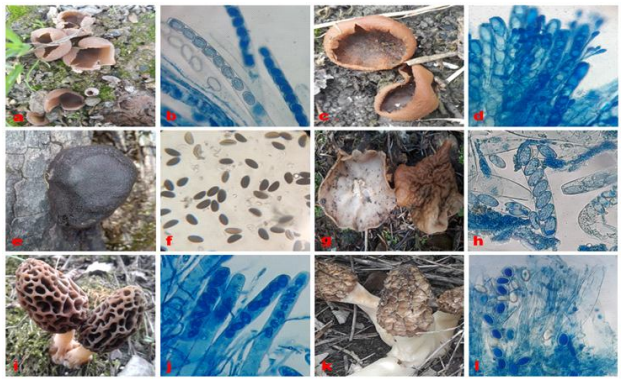

Fig.5. a-l: *Peziza repanda:* a. Ascocarp with recurved cup shaped pileus.b. Asci with eight elliptical ascospores (400x); ***Peziza badia:*** c. Cup shaped ascocarp without stipe.d. Asci with ellipsoidal ascospores (400x); ***Daldinia concentrica:*** e. Cushion shaped Ascocarp without stipe. f. Elliptical ascospores without asci (1000x); ***Disciotis venosa:*** g. fruiting body with central wrinkles, upper as well as lower view. h. Asci with eight elliptical ascospores (400x); ***Morchella esculenta:*** i. Pale brownish to greyish brown fruiting body showing pileus and stipe. j. Asci with ellipsoidal ascospores (400x); ***Morchella crassipes:*** k. Fruiting body showing pileus and stipe. l. Asci with eight ellipsoidal ascospores (400x).

Bankoot, Malangam, main Bandipora and Warpora exhibited less or negligible Ascomycetous mushrooms diversity while as other study sites revealed the occurance of more or less similar species in terms of their distribution with Gulmarg and Handwara as dominant sampling sites from Northern Kashmir.

Likewise, two-way cluster analysis (Fig. 8) expresses the degree of similarity between reported Ascomycetous mushrooms and the

study sites from North Kashmir. From the two-way cluster analysis three clusters were formed corresponding to surveyed sites and distribution of reported mushrooms. Majority of the surveyed sites revealed the presence of similar Ascomycetous mushroom species. However, no single Ascomycetous mushroom was reported from Warpora, Malangam, Bankoot and main Bandipora.

Edibility of documented Ascomycetous macrofungi

It was revealed from the current study (Fig. 9) that majority of the documented Ascomycetous mushrooms were found to be edible (46%), followed by edible but not recommended (21%), inedible but non-poisonous (21%), inedible but poisonous (8%) and unknown (4%).

DISCUSSION

Due to conducive climatic conditions in Kashmir Valley, a rich repository of mushrooms have been explored by many workers but less work has been carried out for exploration of Ascomycetous mushrooms (Walting and Gregory, 1980; Wani *et al.* 2010, 2015; Malik *et al.* 2018; Talie *et al.* 2021). The present study revealed the information and documentation of (24) species of the Ascomycetous mushrooms belonging to (10) genera, (07) families, and (02) orders from North Kashmir, India. The order Pezizales was found with highest (23) macrofungi species while as order Xylariales revealed the occurance of only (01) species. Likewise, the family Morchellaceae showed highest (09) number of species, followed by Helvellaceae (05), Discinaceae (04), Pyronemataceae (02), Pezizaceae, Sarcoscyphaceae (02 each), and Xylariaceae (01). There are few reports on Ascomycetous mushrooms from North Kashmir (Malik *et al*. 2018; Talie *et al.* 2021) but studies on proper exploration, authentic identification, and checklist preparation have not been directed earlier. Sharma *et al.* (2022) reported diversity and distribution of 83 macrofungal species from Kishtwar High Altitude National Park, Jammu Region of J&K, India. They reported that majority of the documented macrofungi belong to Basidiomycetes while as few belong to Ascomycetes mushrooms with (14%) Pezizales. These findings were in line with the results of our study were in we documented highest number of species belonging to order Pezizales. The findings of our study agreed with the studies of Debnath *et al.* (2020) who prepared a checklist of macrofungi from the forests of Tripura, India where in authors reported and documented 217 species with majority of Basidiomycetes, followed by a smaller number of Ascomycetes mushrooms. In a similar studies Tapwal et al. (2013) and Singha *et al.* (2017) reported 30 and 71 species of macrofungi from different several regions of India.

The present study, also reported that four species, viz. *Morchella vulgaris, M. quercus, M. kaibabensis* and *Verpa conica* were new records and new additions to the mycoflora of Kashmir as well as Indian mushroom flora. The findings of our research were in accordance with the results of Baroni *et al.* (2018) and Ali *et al.* (2021) who reported and documented various species of true morels, including *M. hispaniolensis, M. kaibabensis, M. peruviana, M. gracilis, M. crassipes, M. elata,* and *M. spongiola* from North America and Pakistan using micro-morphological and phylogenetic analysis. Likewise, Loizides *et al.* (2016) documented a detailed account of eleven species of true morels based on morphological and molecular characterization.

It was quite evident from the present study that majority of the documented macrofungi were extensively distributed in Kupwara district followed by Baramulla and least were reported from Bandipora district. Rainfall and the availability of decomposed organic waste are two examples of natural elements that have an impact on the distribution and abundance of wild macrofungi (Swapna *et al.* 2008; Debnath *et al.* 2017). The presence of mushrooms in plantation sites and forest beds indicates a direct relationship between the mushroom population and the physical health of the forest (Debnath *et al.* 2017). During the current research maximium number of Ascomycetous mushrooms were recorded in rainy seasons which helps in decomposition of dead organic matter. The findings of our study were in line with the results of Gogoi and Parkash (2015) and Debnath *et al.* (2020) who also reported more or less similar findings while documented a number of mushrooms from various locations.

Fig.6. Images a-l: *Morchella vulgaris*: a. Fruiting body showing pileus and stipe. b. Asci with large ellipsoidal ascospores (400x); ***Morchella elata:*** c. Honey comb shaped black to brown fruiting body showing pileus and long stipe. d. Asci with ascospores (400x); ***Morchella kaibabensis*:** e. Fruiting body showing pileus having long pits and creamish stipe. f. Asci with eight ascospores (400x); ***Morchella quercus:*** g. Conical ascocarp showing pileus and short stipe.h. Asci with eight ellipsoidal ascospores (400x); ***Verpa bohemica:*** i. Bell shaped fruiting body showing pileus and stipe. j. Each ascus showing two elongated ascospores (400x); ***Verpa conica:*** k. Thimble shaped fruiting body with pileus and stipe. l. Asci with eight ascospores and paraphyses (400x).

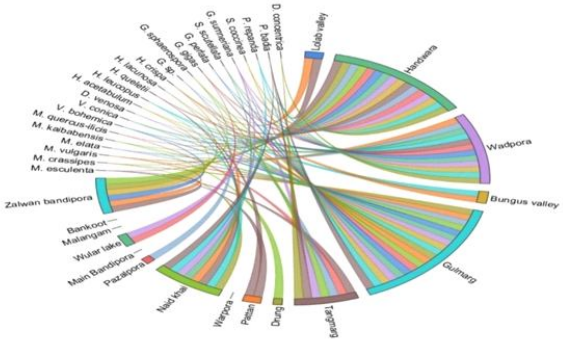

Fig. 7: Linkage between collected mushrooms and study sites. The chord diagram showing distribution of various reported Ascomycetous mushrooms from different study sites of North Kashmir. The size of a circle section corresponds to the spectral counts of surveyed sampling sites, while as the curves connecting them parallel to the amount of spectra shared by two entities like mushroom species and study sites.

CONCLUSIONS

The present study was ardently organised for the documentation of Ascomycetous mushroom diversity from North Kashmir, India and provides the baseline information for further assessment and future research work in different fields. Some of the members belonging to Ascomycetous mushrooms are highly priced due to their nutritional and medicinal importance, however, a mere work has been carried out on their exploration especially in north Himalayan parts

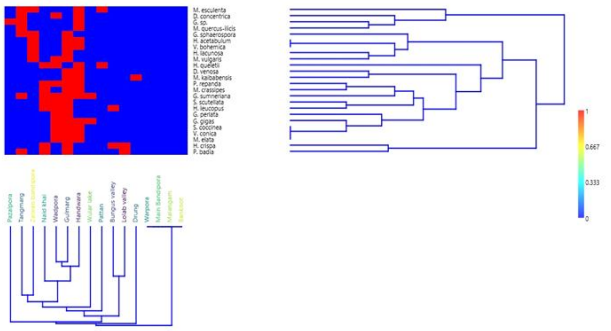

Fig. 8: Two-way cluster analysis using Euclidian's cluster method showing presence of different Ascomycetous mushroom species among sampled sites of North Kashmir.

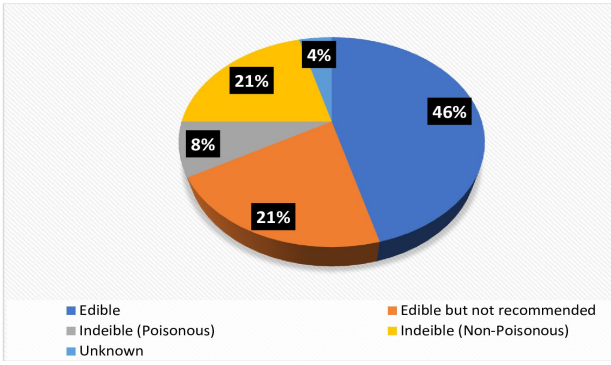

Fig. 9: Proposed edibility of documented Ascomycetous mushrooms

of Jammu and Kashmir. The current study has provided understanding on genetic diversity, distribution, edibility and sustainable exploration of wild Ascomycetous macrofungi from north Kashmir. However, the various biological activities, cultivation methods, edibility, and economic importance of some of the documented Ascomycetous macrofungi are still unknown to us. Therefore, additional research is required to develop various cultivation techniques as well as to isolate the functionally active components of these wild mushrooms for their medicinal attributes. The importance of mushroom diversity is not only for the bionetwork but also for human diet and health, which are necessary reasons for their conservation.

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DECLARATIONS

Conflict of interest: Authors declare no conflict of interest.

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