PROCEEDINGS OF THE YEREVAN STATE UNIVERSITY

Chemistry and Biology 2019, **53**(1), p. 33–41

Biology

THE DIVERSITY AND DISTRIBUTION OF EDIBLE AND MEDICINAL MUSHROOMS FROM MAZANDARAN PROVINCE OF NORTHERN IRAN

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The present study was conducted in Mazandaran Province of Northern Iran. A total of 76 species and 2 variations of macrofungi belonging to phyla Basidiomycota and Ascomycota have been collected and identified. Among described species, 54 are edible, 24 possess only medicinal properties, 15 are reported for the first time for Mazandaran Province and 3 *Russula* species – for mycobiota of Iran. From them 42 species grow on northern slopes, 12 – on southern slopes, and 29 – on all facing slopes. They belong to xylotrophs (37), coprotrophs/xylotrophs (3), humus/litter saprotrophs (17) and mycorrhizal (20) species.

***Keywords*:** medicinal and edible mushrooms, diversity, distribution, ecological groups, Northern Iran.

Introduction. Currently, about 140 000–160 000 species of mushrooms or macrofungi is estimated on Earth of which only 10% (14 000–16 000) are scientifically known [1–3]. Mushrooms are considered sources of protein, lipids, minerals, vitamins, trace elements, and dietary fibers [4–6]. About 7000 known mushroom species are considered edible and about half of these are highly regarded [7]. In spite of huge biotechnological potential of macrofungi [5, 7], their biodiversity in different parts of the world has not been sufficiently investigated and the resource value is underestimated. The first report about the distribution of mushrooms in the territory of Iran was written by Boissier and Buhse in 1860 [8]. Further studies of Iranian mycoflora were published by several local and international researchers [9–18].

The humid climate and vegetation of Iranian northern forest in Caspian Sea region are favorable for the growth of mushrooms. Despite the rich biodiversity, information about distribution and usage of edible and medicinal mushrooms in this region is quite limited. In this paper, the diversity and distribution of edible and medicinal mushrooms from Mazandaran Province of Northern Iran are presented.

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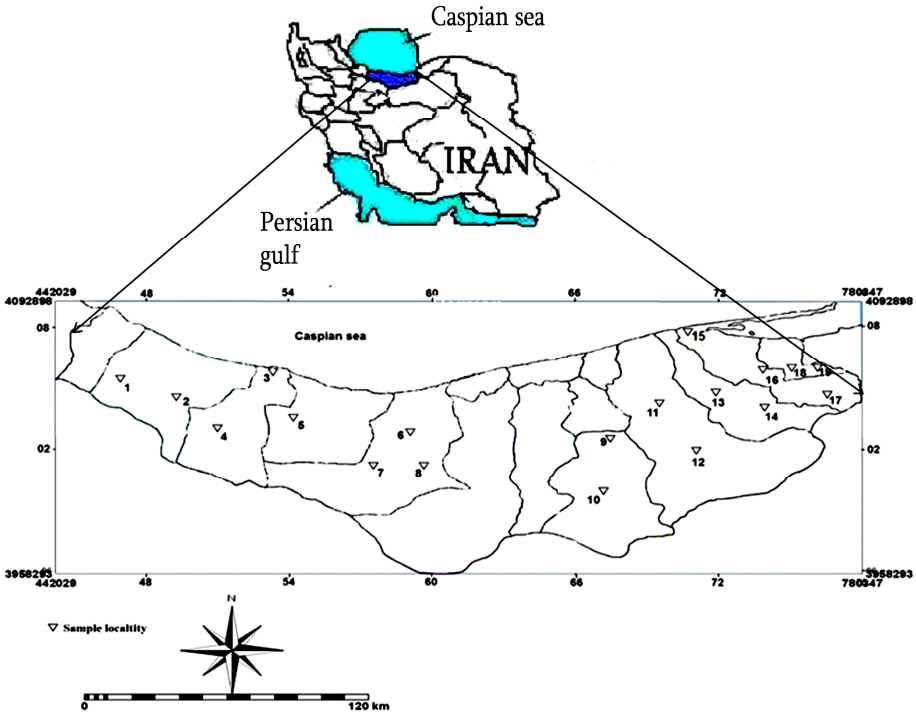
Material and Methods.

Collection Localities. The present study was conducted in Mazandaran Province (35º47'–36º35' N, 50º34'–54º10' E) located in Northern Iran and the central, South of Caspian Sea region or so-called space Hyrcanian zone encompassed by humid deciduous forests (see Figure). The geographical and topographical conditions, as well as the humidity in most of these areas create favorable conditions for the growth of rich mycoflora. The nature of this region is affected by latitude, Alborz Mountain, altitude, and local or regional winds, which create special climate conditions. According to De Martonne aridity index, the climate of Mazandaran Province in western, central, eastern and mountainous areas is highly humid, humid, Mediterranean and semi-humid, respectively. The annual average rainfall in the coastal area is 977 *mm*, reduces from West to East, the maximum and minimum rainfall according to autumn and spring, respectively. The province has a moderate and subtropical climate with an average temperature of 25º*C* in summer and about 8º*C* in winter. Although snow may heavily fall in the mountains in winter, it rarely falls around sea borders.



Map of Mazandaran Province of Northern Iran with collecting sites.

The diversity of forest trees is mainly conditioned by the industrially and commercially important species, such as *Fagus orientalis* L., *Acer velutinum* Boiss, *A. cappadocicum* Gled., *Carpinus betulus* L., *Quercus castaneaefolia* C.A. Mey, *Diospyrus lotus* L., *Zelkova carpinifolia* (Pall.) Dippel, *Ulmus glabra* Huds., *Alnus glutinosa* L., *Parrotia persica* (DC.) C.A. Mey, *Crataegus melanocarpa* Waldst. & Kit. ex Willd. and *Mespilus germanica* Kuntze. The flora of the forest floor consists of *Rubus* spp., *Viola* spp. *Primula* spp., *Cyclamen coum* Mill., *Mentha* spp. and other species.

***Collection and Identification of Mushroom Samples*.** Intensive periodical mushroom inventories in the studied territory were conducted at 2007–2010. The collection of mushrooms has been undertaken in 19 sites numerically arranged on the map of Mazandaran Province from West to East (see Figure). Mushroom inventories were conducted at least once a weak in Behshahr area (indicated by 15, 16, and 17) and erratic times in other regions. The shape, color and smell of basidiomes, characteristics of their habitats (type of forest, host, altitude, slope facing of collection site) and tentative names were written for all collected samples before they were brought to the lab. The spore prints, particularly from Agaricales species, were taken for further microscopic studies.

The collected mushrooms were taxonomically identified using traditional keys and colored field guide books [19–26]. Several polypore specimens were sent to Prof. Ryvarden (Botanical Institute, University of Oslo, Norway) for taxonomic identification and verification. The reference [27] was used for the comparative analysis of mushroom species reported previously from Iran, particularly Mazandaran Province to our list. The collected specimens of mushrooms are deposited at the Mycological herbarium of Passand forest and rangeland station of Mazandaran Province of Iran. In the current paper the taxonomy and nomenclature of collected mushrooms have been revised according to MycoBank Database (http://www.mycobank.org/).

Results and Discussion.

***Diversity and Distribution of Mushrooms*.** Around 180 mushroom species were collected and identified from 2007 to 2010 from Mazandaran forest from which 8 *Russula* species (*R. cyanoxantha*, *R. delica*, *R. fellea*, *R. lepida*, *R. maerii*, *R. rosea*, *R. variata*, *R. virescens*) were originally described for mycoflora of Iran and 42 species from 18 families and 25 genera were reported in Mazandaran province for the first time [28, 29]. Two new fungus-host associations – *D. lotus* and *Z. carpinifolia* were revealed for medicinal fungus *Flammulina velutipes* in Iran [30].

Among described macrofungi, 76 species and 2 variations possess culinary and medicinal properties (see Check list). They are representatives of 4 classes, 11 orders and 34 families of phyla Basidiomycota and Ascomycota of the subkingdom of Dikarya. The basidiomycetous species include Agaricomycetes and Tremellomycetes classes and are represented by 9 orders (Agaricales, Polyporales, Auriculariales, Boletales, Cantharellales, Hymenochaetales, Russulales, Phallales, Tremellales) and 31 families. Ascomycetous species include classes Pezizomycetes and Sordariomycetes and are represented by 2 orders (Pezizales, Xylariales) and 4 familie (see Check list). The most representative order of basidiomycetous mushrooms is Agaricales (38 species and 1 variation), followed by Polyporales (11 species) and Russulales (9 species and 1 variation). The dominant families of edible and medicinal mushrooms described in the studied territory were Agaricaceae (11 species), Polyporaceae (6 species) and Russulaceae (7 species and 1 variation).

Among 78 identified species/variations 14 species (*Agaricus arvensis*, *Amanita rubescens*, *Boletus edulis*, *Coprinopsis atramentaria*, *Coprinellus micaceus*, *Climacodon septentrionalis*, *Daldinia concentrica*, *Hypholoma fasciculare*, *Lactarius piperatus*, *Psathyrella candolleana*, *Pleurotus eryngii*, *P. pulmonarius,*

Phallus impudicus, *Pluteus cervinus*) and 1 variation (*P. cervinus var. album*) were originally reported for Mazandaran Province and 3 *Russula* species (*R. cyanoxantha*, *R. delica* and *R. virescens)* – for mycobiota of Iran. Among them, 54 species are edible and medicinal, while 24 species possess only medicinal effects. The 12 species such as *B. edulis*, *P. ostreatus, Cantharellus cibarius* and *Morchella esculenta* possess excellent edibility (see Check list).

The described species belong to different ecological groups: xylotrophs (37), coprotrophs/xylotrophs (3), humus/litter saprotrophs (17) and mycorrhizal (20) species. 42 species were found on northern (N-17, NE-9, NW-16) and 12 species on southern (SE-4, SW-8) slope directions. Only 29 species have been collected on all slope directions. Northern slope facing, as it was previously reported is characterized with mushroom diversity from late summer to mid-autumn suggested that the most ampleness of mushrooms on Northern Iran grows on northern slope directions in July when the rainfall is high and the temperature ranges 25–28º*C* [28–30]. This is related to the humid climate, the richness of plant hosts in these seasons, and slope directions. The humidity that comes from Caspian Sea and paddy fields of these areas contacts and accumulates more in these slope directions, than in other sides.

The annotated checklist of mushrooms from Mazandaran Province of Northern Iran and their culinary and medicinal properties are provided.

The Checklist of Mushrooms from Mazandaran Province of Northern Iran, Their Culinary and Medicinal Properties

Phylum Basidiomycota
Class Agaricomycetes
Order Agaricales

Family Agaricaceae:

- **Agaricus arvensis* Schaeff. – ED/MM; HS; CS 17, SW slope.
- *Agaricus bernardiformis* – ED; HS; CS 12, N slope.
- *Agaricus campestris* (L.) – ED/MM; HS; CS 15, N slope.
- *Bovista plumbea* Pers. – ED/MM; HS; CS 7, 15, SE slope.
- *Calvatia gigantea* (Batsch.) Lloyd. – ED/MM; HS; CS 7, 16, NW slope.
- *Coprinus comatus* (O.F. Müll.) Pers. – ED/MM; CPT/XT; CS 1, 7, 9, 15, 16, NE slope.
- *Lycoperdon perlatum* Pers. – ED; HS; CS 4, 7, 8, 17; all facing slopes.
- *Lycoperdon pyriforme* Willd. – ED/MM; XT; CS 7, 8, 17; NE slope.
- *Macrolepiota procera* (Scop.) Singer – ED/MM; HS; CS all, all facing slopes.
- *Mycenastrum corium* (Guers.) Desv. – ED/MM; HS; CS 15, NE slope.
- *Vascellum* (=*Lycoperdon*) *pratense* (Pers.) Kreisel – ED/MM; HS; CS 13, N slope.

Family Amanitaceae:

- *Amanita pantherina* – MM; MCR, CS all, all facing slopes.
- **Amanita rubescens* Pers. – ED/MM; MCR; CS 8, 15, 17, SW slope.

Family Clavariceae:

- *Clavaria fragilis* (=*vermicularis*) Holmsk. – ED/MM; HS; CS 9, 15, N slope.

Family Hydnangiaceae:

- *Laccaria laccata* (Scop.) Cooke – ED/MM; MCR; CS 6, 17, W and SW slopes.

Family Lyophyllaceae:
- *Calocybe ionides* (Bull.) Donk – ED/MM; HS; CS 7, SW slope.
- *Lyophyllum decastes* (Fr.) Singer – ED/MM; HS; CS 8, N slope.

Family Mycenaceae:
- *Panellus stipticus* (Bull.) P. Karst. – MM; XT; CS all, NW slope.

Family Omphalotaceae
- *Mycetinis* (=*Marasmius*) *alliaceus* (Jacq.) Earle – ED/MM; LS; CS 5, 12, 16, 17; N and NE slopes.

Family Physalacriaceae:
- *Armillaria mellea* (Vahl.) P. Kummer – ED/MM; XT; CS all, all facing slopes.
- *Flammulina velutipes* (Curtis) Singer – ED/MM; XT; CS all, all facing slopes.
- *Hymenopellis* (=*Oudemansiella*) *radicata* (Relhan) R.H. Petersen – MM; XT; CS all, N slope.

Family Pleurotaceae:
- *Pleurotus cornucopiae* (Paulet) Rolland– ED/MM; XT; CS all, all facing slopes.
- *Pleurotus ostreatus* (Jacq.) P. Kummer – ED/MM; XT; CS all, all facing slopes.
- **Pleurotus eryngii* (D.C.) Quél. – ED/MM; XT; CS all, all facing slopes.
- **Pleurotus pulmonarius* (Fr.) Quél. – ED/MM; XT; CS all, all facing slopes.

Family Pluteaceae:
- **Pluteus cervinus* (Schaeff.) P. Kumm. – ED/MM; XT; CS 8, 15, 17, N slope.
- **Pluteus cervinus var. albus* Vellinga – ED; XT; CS 11, 15, N, NE slopes.
- *Volvariella bombycina* (Schaeff.) Singer – ED/MM; XT; CS 9, 15, 17, all facing slopes.
- *Volvariella gloiocephala* (DC.) Boekhout & Enderle – ED/MM; HS; CS 13, N slope.

Family Psathyrellaceae:
- **Coprinopsis atramentaria* (Bull.: Fr.) Redhead, Vilgalys & Moncalvo – MM; CPT/XT; CS 15, 16, 18, NE slope.
- **Coprinellus micaceus* (Bull.) Vilgalys, Hopple & Jacq. Johnson. – MM; CPT/XT; CS 8, 16, 18, N slope.
- **Psathyrella candolleana* (Fr.) Maire – MM; LS; CS 7, 14, all facing slopes.

Family Schizophyllaceae:
- *Schizophyllum commune* Fr. – MM; XT; CS all, all facing slopes.

Family Strophariaceae:
- *Cyclocybe aegerita* (V. Brig.) Vizzini (=*Agrocybe cylindracea* (DC.) Vizzini & Angelini) – ED/MM; XT; CS all, all facing slopes.
- **Hypholoma fasciculare* (Huds. : Fr.) Kumm. – MM; XT; CS 1, 4, 7, 9, 10, 16, 17, all facing slopes.

Family Tricholomataceae:
- *Artomyces* (=*Clavicorona*) *pyxidatus* (Pers.) Jülich – ED/MM; XT; CS 7, 17, SE slopes.
- *Tricholoma portentosum* (Fr.) Quél. – ED; MCR, CS 7, N slope.
- *Clitocybe nebularis* (Batsch) P. Kumm. – ED/MM; LS; CS 15, NE slope.

Order Auriculariales

Family Auriculariaceae:
- *Auricularia auricula-judae* (Bull.) J. Schröt. – ED/MM; XT; CS 7, 9, 15, 17, all facing slopes.
- *Auricularia mesenterica* (Dicks.) Pers. – MM; XT; CS all, all facing slopes.

Order Boletales

Family Boletaceae:

- **Boletus edulis* Bull. – ED/MM; MCR; CS 7, 9, 15, N slope.
- *Leccinum scabrum* (Bull.) Gray – ED/MM; MCR; CS 7, N slope.
- *Xerocomus chrysenteron* (Bull.) Quél. – ED/MM; MCR; CS 15, NW slope.
- *Xerocomus porosporus* (Imler ex G. Moreno & Bon) Contu – ED/MM; MCR; CS 7, N slope.

Family Suillaceae:

- *Suillus collinitus* (Fr.) Kuntze – ED/MM; MCR; CS 12, N slope.

Order Cantharellales

Family Cantharellaceae:

- *Cantharellus cibarius* Fr.– ED/MM; MCR; CS 6, 7, 12, 15, 17, all facing slopes.
- *Cantharellus infundibuliformis* – ED; MCR; CS 6, 17, N slope.

Family Clavulinaceae:

- **Clavulina cinerea* (Bull.) J. Schröt. – ED/MM; MCR; CS 9, 15, SE slope.

Family Hydnaceae:

- *Hydnum repandum* L. – ED/MM; MCR; CS 7, 10, NW slope.

Order Hymenochaetales

Family Hymenochaetaceae:

- *Phellinus igniarius* (L.) Quél. – MM; XT; CS 7, 15, SW slope.

Order Phallales

Family Phallaceae:

- **Phallus impudicus* L. – ED/MM; HS; CS 9, 16, N and SE slopes.

Family Phanerochaetaceae:

- **Climacodon septentrionalis* (Fr.) P. Karst. – MM; XT; CS 8, 15, 17, all facing slopes.

Order Polyporales

Family Fomitopsidaceae:

- *Laetiporus sulphureus* (Bull.) Murril – ED/MM; XT; CS 3, 7, 9, 15, 17; all facing slopes.

Family Ganodermataceae:

- *Ganoderma adspersum* (Schulzer) Donk – MM; XT; CS 2, 4, 7, 9, 11,15, 17, all facing slopes.
- *Ganoderma lucidum* (Curtis) P. Karst – MM; XT; CS all, all facing slopes;
- *Ganoderma tsugae* Murril – MM; XT; CS 12, NW slope.

Family Meripilaceae:

- *Meripilus giganteus* (Pers.) P. Karst. – MM; XT, CS 9, 15, 17, SW and NW slopes.

Family Polyporaceae:

- *Fomes fomentarius* (L.) Fr. – MM; XT; CS all, all facing slopes.
- *Lenzites betulina* (L.) Fr. – MM; XT; CS 7, 15, 17, NW slope.
- *Polyporus squamosus* (Huds.) Fr. – ED/MM; XT; CS 7, 15, NW and SW slopes.
- *Pycnoporus cinnabarinus* (Jacq. : Fr.) P. Karst. – MM; XT; CS 7, 15, all facing slopes.
- *Trametes versicolor* (L.) Llyod – MM; XT; CS all, all facing slopes.
- *Trichaptum biforme* (Fr.) Ryvarden – MM; XT; CS 9, 11, 15, 17, all facing slopes.

Order Russulales

Family Hericiaceae:

- *Hericium erinaceus* (Bull.) Pers. – ED/MM; XT; CS 19, N slope.
- *Hericium cirrhatum* (Pers.) Nikol (=*Creolophus cirrhatus*) – ED/MM; XT; CS 15, SW slope.

Family Russulaceae:

- *Lactarius deliciosus* (L.) Gray – ED/MM; MCR; CS 7, N slope.
- **Lactarius piperatus* (L.) Pers. – MCR; CS 15, NW slope.
- *Lactarius volemus* (Fr.) Fr. – ED/MM; MCR; CS 15, NW slope.
- *Lactarius camphoratus* (Bull.) Fr. – ED/MM; MCR; CS 11, NW slope.
- *Russula cyanoxantha var. variata* (Banning) Singer – ED; MCR; CS 11, NW slope.
- ***Russula cyanoxantha* (Schaeff.) Fr.– ED/MM; MCR; CS 15, NW slope.
- ***Russula delica* Fr. – ED/MM; MCR; CS 15, NW slope.
- ***Russula virescens* (Schaeff.) Fr. – ED/MM; MCR; CS15, NE slope.

Family Stereaceae:

- *Stereum hirsutum* (Willd.) Pers. – MM; XT; CS all, all facing slopes.

Class Tremellomycetes

Order Tremellales

Family Tremellaceae:

- *Tremella mesenterica* Retz. – ED/MM; XT; CS 7, 15, all facing slopes.

Phylum Ascomycota

Class Pezizomycetes

Order Pezizales

Family Morchellaceae:

- *Morchella esculenta* (L.) Pers. – ED/MM; HS; CS 3, 15,17, 18, 19, N slope.

Class Sordariomycetes

Order Xylariales

Family Hypoxylaceae:

- **Daldinia concentrica* (Bolton) Ces. & De Not. – MM; XT; CS all, all facing slopes.

Family Xylariaceae:

- *Xylaria polymorpha* (Pers.) Grev. – MM; XT; CS all, all facing slopes.

* – new species for Mazandaran Province; ** – new species for mycoflora of Iran.

Abbreviations: CPT (coprotrophs); CS (collection site); ED (edible); HS (humus saprotrophs); LS (litter saprotrophs); MCR (mycorrhizal); MM (medicinal mushrooms); N (North); NE (North-East); NW (North-West); SW (South-West); W (West); XT (xylotrophs).

Conclusion. The study of diversity and distribution of edible and medicinal mushrooms in Mazandaran Province of Northern Iran has been originally performed. The identified 78 species belonging to 11 orders and 33 families, 4 classes and 2 phyla Basidiomycota and Ascomycota. Among them, 14 species (*A. arvensis, A. rubescens*, *B. edulis*, *C. atramentaria*, *C. micaceus*, *C. septentrionalis*, *D. concentrica*, *H. fasciculare*, *L. piperatus*, *P. candolleana*, *P. eryngii*, *P. pulmonarius*, *P. impudicus*, *P. cervinus*) and 1 variation (*P. cervinus var. album)* were reported for the first time in Mazandaran Province and 3 *Russula* species (*R. cyanoxantha*, *R. delica* and *R. virescens*) – for mycobiota of Iran. The described

species belong to xylotrophs, soil/litter saprotrophs and mycorrhizal species. The checklist of mushrooms is presented. The obtained results could have a significant contribution to the study of fungal biodiversity of Iran.

The authors thank Prof. L. Ryvarden (Botanical Institute, University of Oslo, Norway) for his kind assistance in identifying polypore specimens, as well as S.A. Mossazadeh for his support in the collection and identification of mushroom samples.

Received 10.01.2019
Reviewed 25.01.2019
Accepted 05.03.2019

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