

Some Rust Fungi of Higher Plants in Zarafshan National Nature Park

Gavkhar Furkatovna Umurzakova, Guljakhon Komiljon Kizi Norimova,
Zebiniso Iskandarovna Umurzakova

Department of Botany, Samarkand State University Named after Sharof Rashidov, Samarkand, Uzbekistan
Email: narimovaguljaxon@gmail.com

How to cite this paper: Umurzakova, G.F., Norimova, G.K.K. and Umurzakova, Z.I. (2026) Some Rust Fungi of Higher Plants in Zarafshan National Nature Park. *American Journal of Plant Sciences*, 17, 621-629. <https://doi.org/10.4236/ajps.2026.176038>

Received: February 5, 2026

Accepted: June 8, 2026

Published: June 11, 2026

Copyright © 2026 by author(s) and Scientific Research Publishing Inc.
This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).
<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

This article presents data on rust fungi identified during mycological investigations. As a result of the analyses, it was recorded that 23 species of rust fungi belonging to 1 class, 1 order, 4 families, and 5 genera are distributed on higher plants in the Zarafshan National Nature Park, occurring on 24 species of higher plants belonging to 6 families and 22 genera. The analysis showed that 23 species of rust fungi belong to the division Basidiomycota, order *Pucciniales*, and the families *Pucciniaceae*, *Phragmidaceae*, *Melampsoraceae*, and *Gymnosporangiaceae*. Based on the collected herbarium specimens, species of the genera *Puccinia* (13 species), *Phragmidium* (2 species), *Melampsora* (3 species), *Uromyces* (4 species), and *Gymnosporangium* (1 species) were found to cause rust disease on their host plants. All these fungi are plant parasites and are generally highly specialized with respect to the host plant species they infect.

Keywords

Phragmidium, *Melampsora*, *Gymnosporangium*, *Puccinia*, *Uromyces*, Rust, *Micromycetes*

1. Introduction

Global climate change on our planet, together with the impacts of biotic, abiotic, and anthropogenic factors on ecosystems, leads to both negative and positive changes in the ecological and biological characteristics of microorganisms. Identifying the causes and underlying patterns of these changes makes the study of the systematics, geographical distribution, and biological characteristics of fungi one of the most pressing research priorities.

Currently available mycological data do not fully synthesize information on the distribution patterns, systematics, geography, and ecology of *Micromycetes* oc-

curing across all geographical regions of the Republic of Uzbekistan. This is primarily due to the fact that the *Mycobiota* of higher plants in certain regions of the country have not been systematically studied; the Zarafshan National Nature Park is among such insufficiently investigated areas.

A comprehensive investigation of the species composition, geographical distribution, and biological characteristics of *Micromycetes* occurring on higher plants in the Zarafshan National Nature Park is therefore required. In addition, studying the ecological dependence and seasonal development patterns of *Micromycetes* associated with higher plants in the park is of significant scientific and practical importance.

At present, there are nine national nature parks in Uzbekistan. Among them, the Zarafshan National Nature Park is distinguished by its geographical location and its unique riparian (tugai) vegetation and floristic composition. The park was established in 2018 on the basis of the Zarafshan Nature Reserve, which had been founded in 1975.

The Zarafshan National Nature Park is located in the middle part of the Turkestan and Zarafshan mountain ranges. It is supplied with water by the Zarafshan River and its tributaries. The Zarafshan River is one of the largest river systems in Uzbekistan and Central Asia, extending approximately 770 km from east to west. Owing to the diversity of soil and climatic conditions, the Zarafshan Valley possesses a distinctive natural environment. For this reason, the Zarafshan River basin is divided into three parts: the upper, middle, and lower Zarafshan. The Zarafshan National Nature Park (with an area of approximately 2426.4 ha) is situated in the middle reaches of the Zarafshan River [1] [2] (Figure 1).



Figure 1. Zarafshan National Nature Park (39°40'10"N, 67°05'43"E).

2. Research Object and Methods

Groundwater in this area occurs at shallow depths, and four soil types are distin-

guished: marsh-meadow, alluvial-meadow, meadow-marsh, and marsh soils. The vegetation of the Zarafshan National Nature Park belongs to the tugai (riparian) plant group, and at present the park's flora comprises 61 families, 229 genera, and 416 species of higher plants [1] [2]. These plants form various formation associations, including herbaceous, shrubby, and arboreal communities, which create complex assemblages within the river valley. Tree and shrub vegetation is mainly composed of the following forest-forming species: *Populus alba*, *Populus pruinosa*, *Populus diversifolia*, *Populus nigra*, *Salix olgae*, *Salix turanica*, *Salix wilhelmsiana*, *Salix songorica*, *Elaeagnus angustifolia*, *Platanus orientalis*, *Gleditsia triacanthos*, *Robinia pseudoacacia*, *Ailanthus altissima*, *Acer platanooides*, and *Tamarix pentandra*, among others (Figure 1).

Field studies were conducted during the spring, summer, and autumn seasons. Mycological herbarium specimens collected during route-based field surveys were analyzed in the Laboratory of Botanical and Herbarium Research at Samarkand State University named after Sharof Rashidov. Macro- and micromorphological examinations of micromycete herbarium materials were carried out using trinocular MED D30T LCD and N-300M microscopes. The study of fungal morphological and disease symptoms, as well as species identification, was performed based on relevant scientific literature [3]-[6]. In addition, identification of the recorded pathogenic *micromycetes* was verified using the databases (<https://www.mycobank.org>, <https://www.indexfungorum.org>), while host plant nomenclature followed by GBIF (<https://www.gbif.org/>).

Field surveys were conducted during the growing seasons of 2024 and 2025 across four fixed routes covering diverse habitats within Zarafshan National Nature Park. Host plants were selected using a combination of the "random walk" method and targeted inspections of species known to be susceptible to rust fungi. A substantial sampling effort was made, totaling 250 field hours, to ensure a comprehensive inventory of the park's *Mycobiota*.

3. Results

According to the conducted research, 23 species of rust fungi belonging to 1 class, 1 order, 4 families, and 5 genera were recorded on higher plants in the Zarafshan National Nature Park. These fungi were found infecting 24 species of higher plants belonging to 6 families and 22 genera.

Rust fungi are obligate parasites and do not persist in nature as saprotrophs. They belong to the order *Pucciniales*, which comprises 28 families, approximately 214 genera, and about 9636 species (<https://www.gbif.org/>). In terms of host plant range and impact, *Pucciniales* represents one of the most important orders within the division *Basidiomycota*. All members of this group are plant parasites and are generally highly specialized with respect to their host plant species. They penetrate host plant tissues either through stomata or by directly piercing epidermal cells. Within the tissues, both primary and secondary mycelia grow intercellularly and form characteristic haustoria. At present, the systematics of rust fungi is based on

the structure of their spores (spermatia, teliospores, aeciospores, urediniospores, and basidiospores) as well as their degree of specialization toward host plants. Within this order, the families *Pucciniaceae* (7,000 species), *Raveneliaceae* (397 species), *Phragmidiaceae* (321 species), *Phakopsoraceae* (314 species), *Cloesporiaceae* (204 species), *Melampsoraceae* (192 species), *Pucciniastraceae* (188 species), *Uropyxidaceae* (177 species), *Cronartiaceae* (132 species), and *Gymnosporangiaceae* (121 species) are dominant in terms of species richness (<https://www.mycobank.org>, <https://www.indexfungorum.org>, <https://www.gbif.org/>).

Table 1. Distribution of rust fungi on host plants and the degree of infection.

Names of Fungi	Host Plant	Locality (Jambay District, Zarafshan Park)	Date
<i>Gymnosporangium confusum</i> Plowr.	<i>Crataegus turkestanica</i> Pojark.	39°46'N, 67°08'E	12 May 2025
<i>Melampsora pruinosa</i> Tranzschel.	<i>Populus pruinosa</i> Schrenk.	39°47'N, 67°09'E	20 May 2025
<i>Melampsora farinosa</i> (Pers.) J. Schröt.	<i>Salix alba</i> L.	39°45'N, 67°07'E	15 May 2025
<i>Melampsora tremulae</i> Tul. & C. Tul.	<i>Populus alba</i> L.	39°46'N, 67°08'E	18 May 2025
<i>Phragmidium tuberculatum</i> Jul. Müll.	<i>Rosa canina</i> L.	39°47'N, 67°10'E	10 May 2025
<i>Phragmidium rubi-idaei</i> (DC). P. Karst.	<i>Rubus caesius</i> Thunb	39°46'N, 67°09'E	22 May 2025
<i>Uromyces acetosae</i> J. Schröt	<i>Rumex crispus</i> L.	39°45'N, 67°08'E	05 May 2025
<i>Uromyces polygoni-avicularis</i> Saccardo.	<i>Polygonum aviculare</i> L.	39°47'N, 67°11'E	25 May 2025
<i>Uromyces poae f. poae</i> Rabenh.	<i>Poa bulbosa</i> L.	39°46'N, 67°07'E	14 May 2025
<i>Uromyces leptodermus</i> Syd. & P. Syd.	<i>Setaria viridis</i> (L.) P. Beauv.	39°45'N, 67°10'E	28 May 2025
<i>Puccinia cousiniae</i> P. Syd & Syd.	<i>Arctium refractum</i> (Bornm.) S. López, Romasch., Susanna & N. Garcia	39°46'N, 67°08'E	30 May 2025
<i>Puccinia taraxaci</i> Plowr.	<i>Taraxacum</i> sect. <i>Taraxacum</i> F. H. Wigg.	39°44'N, 67°06'E	12 May 2025
<i>Puccinia malvacearum</i> Bertro ex Mont.	<i>Malva pusilla</i> Sm.	39°45'N, 67°09'E	16 May 2025
<i>Puccinia graminis</i> subsp. <i>lolii</i> W. L. Waterh	<i>Lolium persicum</i> Boiss. & Hohen.	39°46'N, 67°08'E	21 May 2025
<i>Puccinia daniloi</i> Bubák.	<i>Tripidium ravennae</i> (L.) H. Scholz	39°47'N, 67°12'E	19 May 2025
<i>Puccinia acroptili</i> P. Syd & Syd.	<i>Rhaponticum repens</i> (L.) Hidalgo.	39°45'N, 67°11'E	23 May 2025
<i>Puccinia cesatii</i> J. Schröt.	<i>Bothriochloa ischaemum</i> (L.) Keng.	39°46'N, 67°10'E	26 May 2025
<i>Puccinia graminis f. tritici</i> Erikss.	<i>Triticum aestivum</i> L.	39°47'N, 67°08'E	15 May 2025
<i>Puccinia bromina</i> Erikss.	<i>Bromus oxyodon</i> Schrenk.	39°45'N, 67°07'E	11 May 2025
<i>Puccinia carthami</i> Codra.	<i>Carthamus tinctorius</i> L.	39°46'N, 67°09'E	29 May 2025
<i>Puccinia cnici</i> (F. Strauss) H. Mart.	<i>Cirsium vulgare</i> (Savi) Ten.	39°47'N, 67°11'E	17 May 2025
<i>Puccinia striiformis</i> Westend.	<i>Calamagrostis pseudophragmites</i> (Haller f.) Koeler.	39°46'N, 67°10'E	13 May 2025
<i>Puccinia carduorum</i> Jacky.	<i>Carduus pycnocephalus</i> subsp. <i>albidus</i> (M. Bieb.) Kazmi	39°45'N, 67°08'E	24 May 2025
	<i>Carduus nutans</i> subsp. <i>nutans</i>	39°47'N, 67°11'E	17 May 2025

Twenty-three species of rust fungi belonging to the division Basidiomycota were analyzed and found to belong to the order *Pucciniales* and the families *Pucciniaceae*, *Phragmidaceae*, *Melampsoraceae*, and *Gymnosporangiaceae*. Based on the collected herbarium specimens, species of the genera *Puccinia* (13 species), *Phragmidium* (2 species), *Melampsora* (3 species), *Uromyces* (4 species), and *Gymnosporangium* (1 species) were confirmed to cause rust disease on their host plants (**Table 1**).

The degree of infection was assessed visually using a 4-point scale (0: absent, 1: low/scattered lesions, 2: moderate, 3: severe/extensive sori coverage). This standardized approach allowed for a rapid yet consistent estimation of pathogenicity across different host species.

***Pucciniaceae* Chevall, *Puccinia* Pers.**

Spermogonia of *Puccinia* species are located on both sides of the host plant leaves, predominantly on the upper surface, beneath the epidermis; they are globose, contain paraphyses, and are colorless. Aecia occur on both sides of the host leaves, mainly on the lower surface, as well as on leaf veins and fruits. The peridium is cup-shaped or cylindrical, with margins often turned outward. Aeciospores are produced in chains, with a colorless or pigmented wall, appearing smooth or spiny. Uredinia develop on both sides of the host leaves, appearing powdery, sometimes forming concentric rings. They may be paraphysate or non-paraphysate. Urediniospores are single, borne on pedicels, with a wall that is spiny or smooth, and have germ pores. Telia are found on the leaves and stems of the host plant, appearing dense or powdery, and dark in color. Teliospores are single, borne on pedicels, typically 1 - 2 (sometimes 3 - 5) celled ($16.6 - 26.4 \times 19.8 - 29.7$ mkm, *Puccinia cousiniae*). The wall is smooth or ornamented, occasionally with apical crown-like projections. Each cell contains one germ pore [3]-[6] [8]-[12].

***Uromyces* (Link) Unger.**

Spermogonia of *Uromyces* species are found on both sides of the host plant leaves, mainly on the upper surface, either in groups or scattered among the aecia, beneath the epidermis ($16.5 - 23.31 \times 16.6 - 19.9$ mkm, *Uromyces polygoni-avicularis*). They are globose or flask-shaped, sometimes with a blunt-conical apex, pigmented, and paraphysate. Aecia develop on both sides of the host leaves, primarily on the lower surface, leaf veins, and stems, beneath the epidermis. They later appear powdery, forming clustered groups, and are pigmented. The peridium (wall) is cup-shaped or cylindrical, composed of cells of various shapes; the outer wall is usually thick, smooth, or striated, while the inner wall is thin and rough (spiny), often interrupted by teeth or fragments. Aeciospores are produced in chains, with smooth or finely spiny walls. Uredinia occur on both sides of the host leaves, mostly on the lower surface, leaf veins, and stems, developing beneath the epidermis. They later become powdery, scattered, grouped, or circular. Urediniospores are single, borne on pedicels, mixed with paraphyses or without, pigmented, with walls that are spiny or smooth, and possessing one or more germ pores. Telia are located on both sides of the host leaves, mainly on the lower sur-

face, leaf veins, and stems, beneath the epidermis. They often penetrate deeply into the mesophyll, appearing open or closed, dense or porous, and dark in color. Teliospores are unicellular, borne singly on pedicels, pigmented, with a smooth or spiny wall, a single germ pore, and pedicels that may be colorless or pigmented, rigid or fragile [3]-[6] [8]-[12].

***Phragmidiaceae* Corda, *Phragmidium* Link, Mag.**

Spermogonia of *Phragmidium* species are located on both sides of the host plant leaves, mainly on the upper surface, developing beneath the cuticle. Their growth is indeterminate, and they consist of hymenia and peridia, occurring singly or in groups, small in size, and yellow in color. Aecia develop on both sides of the host leaves, primarily on the lower surface beneath the epidermis. They later appear powdery, rounded or elongated in shape, small, often merging with one another, and pigmented. They are surrounded by colorless or slightly pigmented cylindrical, bent paraphyses. Aeciospores are produced in chains or singly on pedicels, pigmented, with smooth or occasionally spiny walls. Uredinia develop on the lower surface of host leaves beneath the epidermis, later becoming powdery. They are rounded or elongated, small, and surrounded by bent, cylindrical or club-shaped paraphyses. Urediniospores occur singly, borne on pedicels, and are pigmented. In the studied specimens, urediniospores are pyriform (pear-shaped), elliptical, or subglobose in shape, measuring 19.9 - 21.7 × 15.8 - 17.6 mkm (*Phragmidium tuberculatum*), with colorless or slightly pigmented spiny walls. Telia develop on the lower surface of host leaves beneath the epidermis, later appearing powdery, dark in color, with or without paraphyses. Teliospores are cylindrical, rarely club-shaped, two- or multicellular, with one, two, or more germ pores. They are dark-colored, with or without pedicels, and germinate immediately or after a dormancy period. The spore wall and pedicel have a thin, nearly colorless outer layer and a thick, pigmented, smooth or spiny inner layer. Pedicels vary in shape and size, are colorless, and are often hygroscopic, swelling in response to water [3]-[6] [8]-[12].

***Melampsoraceae* Dietel, *Melampsora* Castagne.**

Spermogonia of *Melampsora* species are located on the upper or lower surfaces of host plant leaves, and sometimes on both sides, developing beneath the epidermis or cuticle. They are semi-globose or blunt-conical in shape, with a flat or slightly hemispherical hymenial layer. Spermata are spherical in shape. Aecia develop on the lower surface of host leaves beneath the epidermis, are flat, cushion-shaped, and lack peridia and paraphyses. Their color ranges from dark orange-yellow to light yellow, fiery red, or yellow. Aeciospores are produced in chains, with a colorless wall, smooth or rod-like in structure. Uredinia develop on both sides of host leaves, mainly on the lower surface, beneath the epidermis, and later appear powdery. They may be without peridia or have a rudimentary peridium that is quickly lost, and are pigmented. Urediniospores occur singly, mixed with blunt or rod-shaped colorless paraphyses, and are pigmented. Their walls are colorless, smooth or spiny, sometimes with a smooth apex. In *Melampsora pruinosa*, urediniospores are typically spherical or elliptical in shape, measuring 23.1

- $36.3 \times 19.8 - 26.4$ mkm. Telia develops on both sides of host leaves, primarily on the lower surface, appearing as one- or multi-layered spots (black lesions). They occur beneath the epidermis or occasionally under the cuticle, dense, and brown to dark brown in color. Teliospores are 1(-2)-celled, germinating after a dormancy period; the wall is thin, pigmented, and smooth [3]-[6] [8]-[12].

***Gymnosporangiaceae* Chevall, *Gymnosporangium* R. Hedw. ex DC.**

Spermogonia of *Gymnosporangium* species are located on the upper surface of host plant leaves, beneath the epidermis, and are globose or oval in shape. They are initially yellow, turning brown as they mature. Aecia develop on the lower surface of host leaves. Their peridia are slit almost to the base, with cells remaining connected laterally. Peridial cells are smooth or striated on the outside, and rough or finely spiny on the inside. Aeciospores are produced in chains, dark brown in color, with spiny walls. Uredinia occur on leaves or young shoots, developing beneath the epidermis and later appearing powdery. Urediniospores are single, with shape and size varying depending on internal structure. Telia develops on the annual shoots and stems of the host plant, forming fusiform (club-shaped) swellings. Teliospores are two- or multicellular, with pigmented, smooth walls, 2(-3) germ pores, and long, sturdy pedicels. In the examined specimens, teliospores are elliptical in shape, measuring $23.31 - 26.64 \times 16.65 - 23.31$ mkm (*Gymnosporangium confusum*) [3]-[6] [8]-[12].

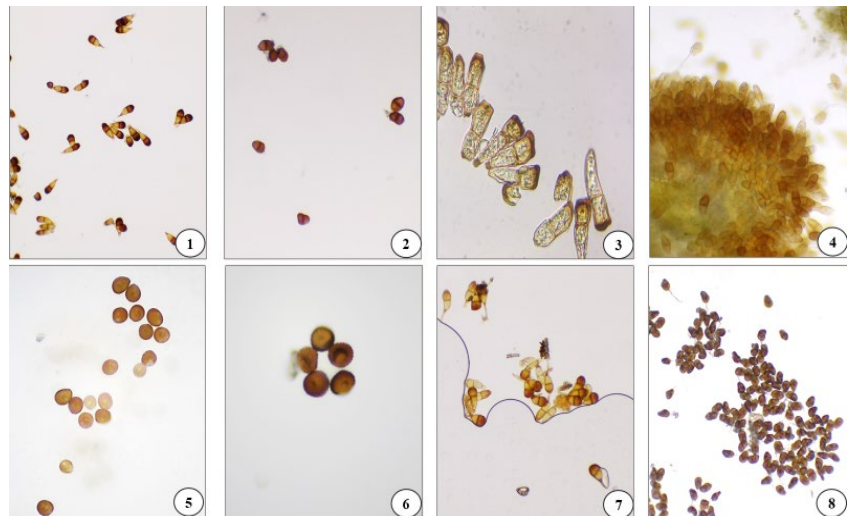


Figure 2. Some rust fungi distributed in the Zarafshan National Nature Park. 1: *Puccinia graminis f. tritici* Erikss., 2: *Puccinia cousiniae* P. Syd & Syd., 3: *Puccinia graminis subsp. lolii* W. L. Waterh., 4: *Puccinia malvacearum* Bertro ex Mont., 5: *Uromyces polygoni-avicularis* Saccardo., 6: *Puccinia taraxaci* Plowr., 7: *Puccinia bromina* Erikss., 8: *Puccinia acroptili* P. Syd & Syd.

Compared to earlier studies in the Samarkand region [3], our findings include 11 species that are newly recorded for Zarafshan National Nature Park. This update is crucial for understanding the current phytopathological status of the region's vascular plants (Figure 2).

4. Conclusion

It was established that the 23 collected species of rust fungi occur on 24 plant species and exhibit pathogenicity. Analysis showed that 23 of these rust fungi belong to 1 division, 1 order, 4 families, and 5 genera: *Melampsora* (3 species), *Gymnosporangium* (1), *Puccinia* (13), *Uromyces* (4), and *Phragmidium* (2). These 22 rust fungi were found to parasitize 24 host plant species belonging to 6 families (Asteraceae, Malvaceae, Poaceae, Polygonaceae, Salicaceae, Rosaceae) and 22 genera (*Rumex* (1 species), *Polygonum* (1), *Poa* (1), *Setaria* (1), *Lolium* (1), *Tripidium* (1), *Botriochloa* (1), *Triticum* (1), *Bromus* (1), *Calamagrostis* (1), *Arctium* (1), *Taraxacum* (1), *Rhaponticum* (1), *Populus* (2), *Carthamus* (1), *Cirsium* (1), *Carduus* (2), *Malva* (1), *Rosa* (1), *Rubus* (1), *Crataegus* (1), *Salix* (1)). It was confirmed that these rust fungi are parasitic on their host plants and are capable of causing rust disease.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

- [1] Kabulova, F., Valiev, S., Jumakulova, N. and Atayeva, S. (2025) Annotated List of Vascular Plants of Zarafshan National Natural Park (Uzbekistan). *Acta Biologica Sibirica*, **11**, 109-135. <https://doi.org/10.5281/zenodo.14810209>
- [2] Kholbutayeva, M., Haydarov, H., Kabulova, F. and Akhmedova, H. (2020) Trees and Shrubs of Zerafshan State National Reserve, Uzbekistan. *American Journal of Plant Sciences*, **11**, 1698-1705. <https://doi.org/10.4236/ajps.2020.1111121>
- [3] Ramazonova, S.S., Faizieva, F.K.H., Sagdullaeva, M.S.H., Kirgizbaeva, K.H.M. and Gaponenko, N.I. (1986) Flora of Fungi of Uzbekistan. Volume III. Rust Fungi. FAN, 232. (In Russian)
- [4] Ulyanishev, V.I. (1978) Opredelitel' rzhavchinnnykh gribov SSSR [Key to Rust Fungi of the USSR]. Nauka, 384. [In Russian]
- [5] Naumov, N.A. (1937) Metody mikologicheskikh i fitopatologicheskikh issledovaniy [Methods of Mycological and Phytopathological Research]. Selkhozgiz, 272. [In Russian]
- [6] Kuprevich, V.I. and Ulyanishev, V.I. (1975) Opredelitel' rzhavchinnnykh gribov SSSR, Chast' I [Key to Rust Fungi of the USSR, Part I]. Minsk, 480. [In Russian]
- [7] Aime, M.C. and McTaggart, A.R. (2020) A Higher-Rank Classification for Rust Fungi, with Notes on Genera. *Fungal Systematics and Evolution*, **7**, 21-47. <https://doi.org/10.3114/fuse.2021.07.02>
- [8] Müller, E. and Löffler, W. (1995) Mykologie [Mycology]. Translated from German. Mir, 344. [In Russian]
- [9] Pidoplichko, N.M. (1977) Parasitic Fungi of Cultivated Plants. Identification Guide. Volume 1. Perfect Fungi. Naukova Dumka, 295. [In Russian]
- [10] Gafforov, Y., Abdurazzokov, A., Yarasheva, M. and Ono, Y. (2016) Rust Fungi from the Fergana Valley, Chatkal and Kurama Mountain Ranges in Uzbekistan. *STAPFLIA*, **105**, 161-175.
- [11] Naumov, N.A. and Kozlov, V.E. (1954) Osnovy Botanicheskoy Mikrotekhniki

- [Fundamentals of Botanical Microtechnique]. Sovetskaya Nauka, 312. [In Russian]
- [12] Kirk, P.M., Cannon, P.F., Minter, D.W. and Stalpers, J.A. (2008) Ainsworth & Bisby's Dictionary of the Fungi. 10th Edition, CAB International.