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Analysis of morphological differentiation and ecological adaptation of *Cytospora* Ehrenb. species in Uzbekistan

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Abstract: This study provides a comprehensive assessment of species of the genus *Cytospora* recorded in Uzbekistan, based on the modern classification framework proposed by Lin et al.. The analysis reveals a clear predominance of representatives belonging to the A-II group, with types A8 and A9 being particularly widespread. These types are characterized by internally complex conidiomatal structures, including multilocular arrangements, central columns, and rosette-like configurations, which appear to enhance reproductive efficiency and spore dispersal. Such structural complexity likely confers a significant adaptive advantage under arid and sharply continental climatic conditions typical of the region.The absence of representatives of the A-I group may indicate either an evolutionary reduction of simple, unilocular stromatic forms or their limited ecological relevance in the studied environment. In contrast, the A-II and A-III groups can be interpreted as relatively advanced stages in the evolutionary trajectory of the genus, reflecting a transition toward increasing morphological and functional specialization. The comparatively low occurrence of A-III group types (A11–A13) may be associated with their narrower ecological amplitude, as these forms tend to occupy more specialized niches despite their structurally differentiated and fully compartmentalized locular systems. The results further demonstrate a strong structural and functional correspondence between asexual (anamorphic) and sexual (teleomorphic) morphs. In particular, the number, arrangement, and internal differentiation of locules in conidiomata show clear parallels with the organization of perithecia in the sexual stage. Multiloculate configurations observed in the A-II group may serve as a developmental basis for the formation of multiple perithecia, whereas discrete locules in A-III types correspond to independently organized or partially fused perithecial systems. Additional features, such as the presence of conceptacle-like structures (black boundary lines), contribute to mechanical stability and protection, and also represent important taxonomic and functional traits across both morphs. A comparative evaluation of the present findings with earlier concepts proposed by Z. Urban [1958] and L. J Spielman [1985] highlights both continuity and conceptual expansion. While previous studies emphasized the taxonomic significance of structural correspondence between ascomatal and conidiomatal components, the present work extends this interpretation by integrating evolutionary and ecological dimensions. Specifically, morphological diversification within the genus is shown to be closely linked with adaptive strategies and reproductive specialization. Overall, the species composition of *Cytospora* in Uzbekistan reflects a dominance of intermediate (A-II) and advanced (A-III) evolutionary forms, underscoring a tight interrelationship between morphological differentiation, ecological adaptation, and the evolution of reproductive systems. These findings contribute to a more integrative understanding of the genus and help bridge gaps between taxonomic, morphological, and evolutionary perspectives.

Keywords: *anamorphic and teleomorphic stages, arid climate adaptation, conidiomatal structure, fungal reproductive strategies, locule differentiation, micromycetes diversity, perithecial arrangement, stromatic organization*

INTRODUCTION

The genus *Cytospora* Ehrenb. was first described and introduced into scientific literature by Ehrenberg in 1818. Members of *Cytospora* are predominantly associated with woody plants. This group-encompassing sexual morphs such as *Leucostoma* (Nitschke) Höhn, *Valsa* Fr., *Valsella* Fuckel, and *Valseutypella* Höhn are widely distributed across the globe and is commonly encountered as endophytes or latent pathogens within healthy plant tissues. However, under conditions of

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of host stress, these fungi may transition into significant disease-causing agents [Schoeneweiss, 1981, 1983]. As of 2023, representatives of the genus *Cytospora* have been recorded from more than 600 host plant species and reported in over 60 countries [Farr, Rossman, 2023].

Recent studies indicate that members of this genus are responsible for a broader spectrum of diseases in trees and shrubs, extending beyond canker formation to include stem dieback, collar rot, and leaf spot symptoms [Palavouzis et al., 2015; Triki et al., 2015; Li et al., 2016]. For instance, *Cytospora lumnitzericola* Norph., T.C. Wen & K.D. Hyde has been reported to cause leaf spot disease on *Lumnitzera racemosa* Willd. [Norphanphoun et al., 2017], while *Cytospora sacculus* (Schwein.) Gvrit. is associated with root rot in *Ziziphus jujuba* Mill. [Du et al., 2013; Chen et al., 2016]. In addition, certain species have also been documented on subshrubs and perennial plants; for example, *Cytospora euphorbiicola* N.Q. Pham, Marinc. & M.J. Wingf. has been identified as a causal agent of dieback in *Euphorbia mauritanica* L. [Marincowitz et al., 2023].

Species of the genus *Cytospora* can be categorized according to their nutritional strategies within host plants into several ecological forms. These include xylotrophic endophytes inhabiting woody tissues (specifically the xylem) [Chapela, 1989], saprotrophs colonizing dead plant material [Christensen, 1940], and epiphytic micromycetes that persist on the surface of plant organs [McIntyre et al., 1996].

Members of this group can express pathogenic traits and cause significant damage to host plants when these hosts experience stress due to various ecological factors. Research indicates that several conditions increase host susceptibility to disease, including drought and elevated temperatures [Gibbs, 1957; Bertrand, English, 1976; Schoeneweiss, 1983; Guyon et al., 1996], nutrient deficiencies [Abebe et al., 1990; Burks et al., 1998], abnormal cold events [Reich & van der Kamp, 1993], and fire occurrences [Dearness & Hansbrough, 1934]. Observations further show that drought and high temperatures have contributed to the enlargement of canker lesions in poplar and apple trees as a result of disease development [Schoeneweiss, 1983; Guyon et al., 1996].

Uzbekistan is characterized by a sharply continental climate, with substantial seasonal temperature contrasts and generally low precipitation, reflecting its location in the arid interior of Central Asia. Summers are typically hot and dry, whereas winters can be relatively cold, particularly in northern and mountainous regions. Spatial and temporal variability of climatic parameters across the country is influenced by atmospheric circulation patterns, topography, and the declining influence of the Aral Sea. Recent studies have also highlighted significant warming trends and increasing climate variability, which have implications for water resources, agriculture, and ecosystem stability [Kholmatjanov et al., 2020; Khaydarov, Gerlitz, 2019].

Despite these environmental conditions, comprehensive studies addressing the distribution, host range, and pathogenicity of *Cytospora* species in Uzbekistan remain lacking. Current knowledge of this genus within the country is primarily based on fragmented records and limited accounts reported in earlier investigations [Zaprometov, 1926, 1928; Golovin, 1947, 1949a, 1949b, 1950; Kleiner, 1958; Gaponenko, 1965; Panfilova & Gaponenko, 1963; Soliyeva, 1989; Komilov, 1991; Nuraliyev, 1998; Gafforov, 2005, 2017; Sherqulova et al., 2019; Mustafaev, 2018; Ortiqov, 2023].

A major challenge underlying this knowledge gap is that morphological characters alone have proven insufficiently reliable for the precise delineation of *Cytospora* species. For instance, Z. Urban [1958] and L. J. Spielman [1985] investigated the relationship between sexual structures (ascomata) and asexual structures (conidiomatal loci), proposing that a certain degree of morphological correspondence should exist between the sexual and asexual stages.

MATERIAL AND METHODS

Study area: Against this background, the ecological and biogeographical features of Uzbekistan play a critical role in shaping host-pathogen dynamics. Uzbekistan is located in Central Asia, sharing international borders with Kazakhstan, Turkmenistan, Tajikistan, and Kyrgyzstan (Fig. 1). The country spans an area of approximately 447,400 km², making it the second-largest nation in the region after Kazakhstan. Uzbekistan is recognized for its considerable biodiversity, encompassing a rich variety of flora and fauna. Current estimates indicate the presence of over 4,500 vascular plant species within its territory, including 334 species that are endemic to the country [Turginov et al., 2019; Islomiddinov et al., 2022].

Morphological classification of Cytospora Ehrenb. species [based on Lin et al., 2024]: Despite these limitations, the identification of *Cytospora* species has traditionally relied primarily on morphological methods. Lin et al. (2024) classified the asexual forms of this genus into three groups (AI–AII) and thirteen types (A1–A13) (Fig. 2).

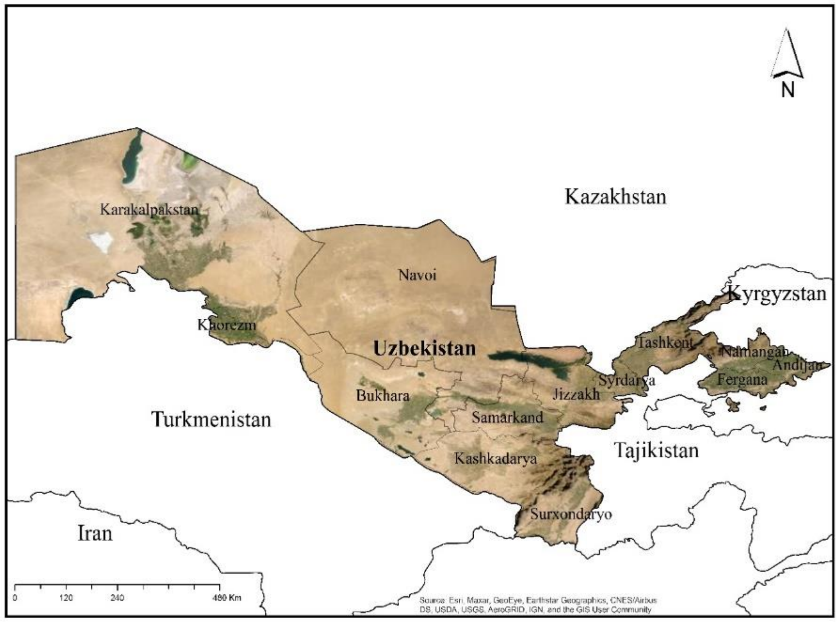

Figure 1. Geographic overview of the study area.

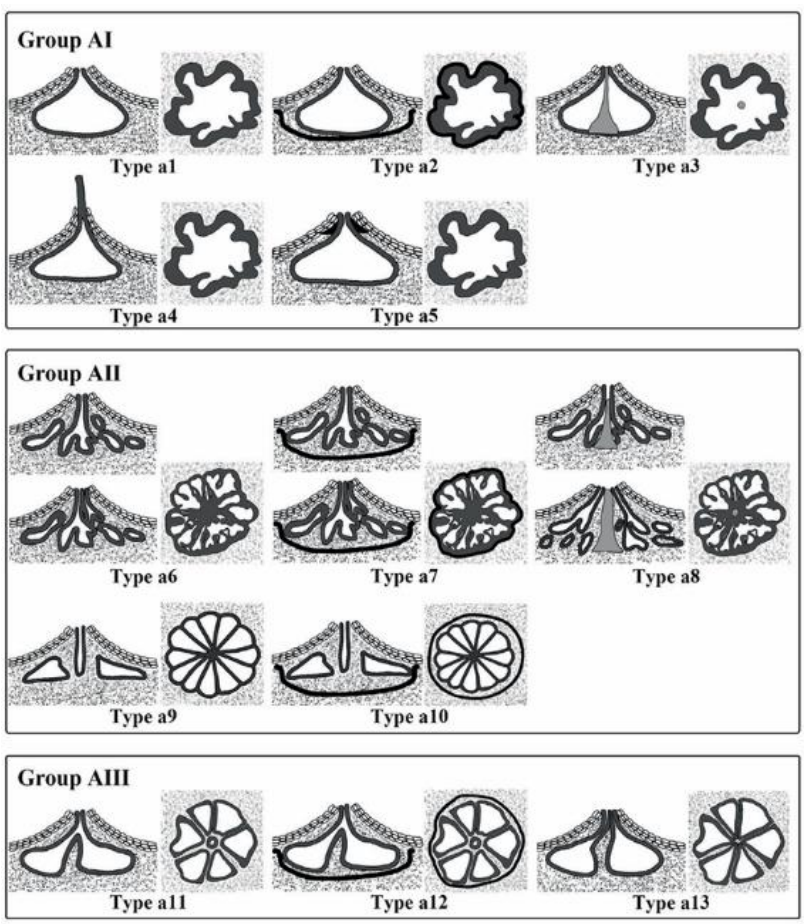

Figure 2. Groups and types of the asexual (anamorphic) forms of the genus *Cytospora* [Lin et al., 2024].

The differentiation of asexual (anamorphic) forms relies on both internal and external morphological characteristics. In particular, the number of locules reflects the complexity of the conidiomata and serves as a key criterion for identifying morphological types. The presence or absence of a conceptacle is associated with protective and structural reinforcement and can function as a diagnostic feature for certain species. Additionally, the development of the central column and ostiole indicates mechanisms of conidial formation and dispersal. Furthermore, whether locules are separated by a common wall or by individual walls determines the level of internal structural complexity of the conidiomata. The combination of these traits enables a systematic classification of asexual forms and facilitates the recognition of interspecific differences.

AI Group: characterized by a single locule: A-I group species are characterized by a single, undivided locule, with variation in the presence of a conceptacle, central column, ostiolar beak, and surrounding ectostroma. Types a1-a5 differ mainly in these structural features, reflecting minor morphological diversity within the group.

AII Group: Composed of multiple locules separated by a common wall. A-II group species are characterized by multiple locules separated by common walls, exhibiting varying degrees of internal chambering, central columns, radial arrangements, and the presence or absence of a conceptacle. Types a6-a10 differ primarily in the complexity of their internal divisions (labyrinthine or radial), the visibility of the conceptacle, and the presence of central columns, while all share multilocularity with common walls and the potential for one or multiple ostioles per disc.

AIII Group: Composed of multiple locules, each separated by individual walls. A-III group species are characterized by multiple locules, each with an independent wall, showing variation in the number and orientation of ostioles and the presence or absence of a conceptacle. Types a11-a13 differ primarily in whether ostioles are multiple and independently oriented or directed toward a single common ostiole, and in the visibility of the conceptacle, while all share the feature of simple, undivided locules without shared walls.

For the identification of sexual (teleomorphic) forms, it has been recommended to classify them into three groups (SI-SIII) and eight types (S1-S8) (Fig.3). The classification of sexual morphological forms is based on both internal and external characteristics. In particular, the number of spores per ascus serves as a key criterion for determining the morphological type. The presence or absence of a dark band (conceptacle) is associated with protection and structural reinforcement and plays an important role in differentiating certain species. Additionally, the number of perithecia and whether they possess individual ostioles or a single common ostiole is significant for species distinction. The combination of these traits enables a reliable classification of sexual forms and allows for the accurate recognition of interspecific morphological differences.

SI Group: Characterized by the presence of numerous ascospores per ascus. Sexual forms (Types s1-s2) are characterized by pseudostromata bounded by conceptacles, with each ascus containing numerous ascospores. Types differ in the arrangement of perithecia: in s1, multiple perithecia possess individual ostioles and are arranged circularly, whereas in s2, all perithecia are directed toward a single common ostiole.

SII Group: Characterized by the presence of eight ascospores per ascus. Sexual forms (Types s3-s7) are characterized by pseudostromata with each ascus containing eight ascospores. Variation among types includes the presence or absence of conceptacles, the arrangement and size of perithecia (circular vs. dense), and the orientation or number of ostioles (individual or directed toward a single common ostiole). These features collectively reflect the morphological diversity and reproductive specialization within the sexual stage.

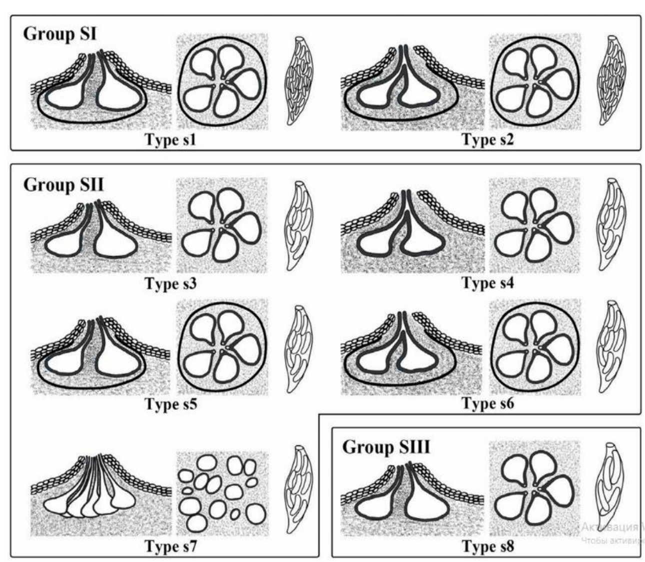

Figure 3. Groups and types of the sexual (teleomorphic) forms of the genus *Cytospora* [Lin et al., 2024]. SIII Group: Characterized by the presence of four ascospores per ascus.

Sexual form (Type s8) is characterized by pseudostromata with each ascus containing four ascospores. Perithecia are arranged circularly, each with an individual ostiole, and pseudostromata are not separated by conceptacles.

Data Sources and Morphological Classification of Cytospora Species: In the preparation of this article, data obtained from the Mycology Herbarium collection of the Botanical Institute of the Academy of Sciences of the Republic of Uzbekistan, as well as from mycological studies conducted across various regions of the country during 2019-2025, served as the primary sources. The classification of *Cytospora* species into groups and types based on their morphological characteristics was conducted in accordance with the methodology proposed by Lin et al. (2024). The current nomenclature of the identified pathogenic micromycetes was based on www.mycobank.org/quicksearch.asp, while host plant names were standardized according to The Plant List (www.theplantlist.org).

RESULTS AND DISCUSSION

The results of mycological investigations conducted across various regions of Uzbekistan, along with data reported in scientific literature from 1926 to 2026, were analyzed for representatives of the genus *Cytospora* Ehrenb. According to this analysis, a total of 31 *Cytospora* species have been identified within the territory of Uzbekistan over the past 100 years (Fig. 4,5,6, Table 1).

These fungi were recorded on 16 plant families, 31 genera, and 64 plant species. Considering the host range and distribution potential of *Cytospora* species, the highest diversity was observed among members of the Rosaceae family (27 host plants, 13 fungal species). This was followed by the Salicaceae (17 hosts/6 fungal species), Elaeagnaceae (4/4), and Ulmaceae (4/2) families. Together, these four families account for 51,7% of all *Cytospora* species identified in Uzbekistan, while the remaining families host only 1-2 micromycete species each.

All *Cytospora* species identified in the region were determined based on morphological characteristics and, to date, no molecular phylogenetic studies have been conducted on representatives of this genus in Uzbekistan.

The *Cytospora* species were analyzed based on the groups and types proposed by Lin et al. (2024), and the results are presented in Table 1. According to the obtained data, among the 31 *Cytospora* species recorded in Uzbekistan, representatives of the A-II group were found to be dominant, specifically with 1 species in type A6, 5 species in type A7, 9 species in type A8, and 7 species in type A9. Additionally, species belonging to the A-III group were also recorded, including 6 species in type A11, 1 species in type A12, and 2 species in type A13.

In this study, the absence of A-I group species may be attributed to the evolutionary decline or ecological insignificance of simple, unilocular (single) conidiomatal stromal forms in this region. This observation supports the notion that evolution within the genus tends to progress from simpler to more complex morphologies. Accordingly, the A-II and A-III groups represent relatively advanced evolutionary stages within the *Cytospora* genus.

The dominance of the A-II group, particularly the abundance of types A8 and A9, may be associated with the ecological stability of the species within these types. These types exhibit complex internal divisions within the locules, central columns, or rosette-like structures, which facilitate spore formation and enhance efficient dispersal. Such morphological features likely provide a significant adaptive advantage under arid and sharply continental climatic conditions.

The comparatively lower representation of the A-III group (types A11-A13) may be related to their tendency toward a stenotopic ecological niche. In this group, the complete separation of locules by individual walls allows for differentiation and the development of complex morphological structures, offering insights into the main spectrum of evolutionary processes within the genus.

The observed results provide clear evidence of an evolutionary link between asexual (anamorphic) and sexual (teleomorphic) forms. Specifically, the number of locules and their degree of internal differentiation show functional correspondence with the number and arrangement of perithecia in the sexual stage. For instance, the multicameral complexes formed through internal divisions in the A-II group may serve as a structural basis for the formation of multiple perithecia in sexual forms, whereas the independent locules in the A-III group correspond to perithecial structures with either separate or common ostioles.

Additionally, the presence or absence of the conceptacle (black border lines) carries evolutionary and ecological significance, providing protection and mechanical stability to the conidiomatal stroma. This feature also manifests as an important taxonomic and functional trait in the sexual forms.

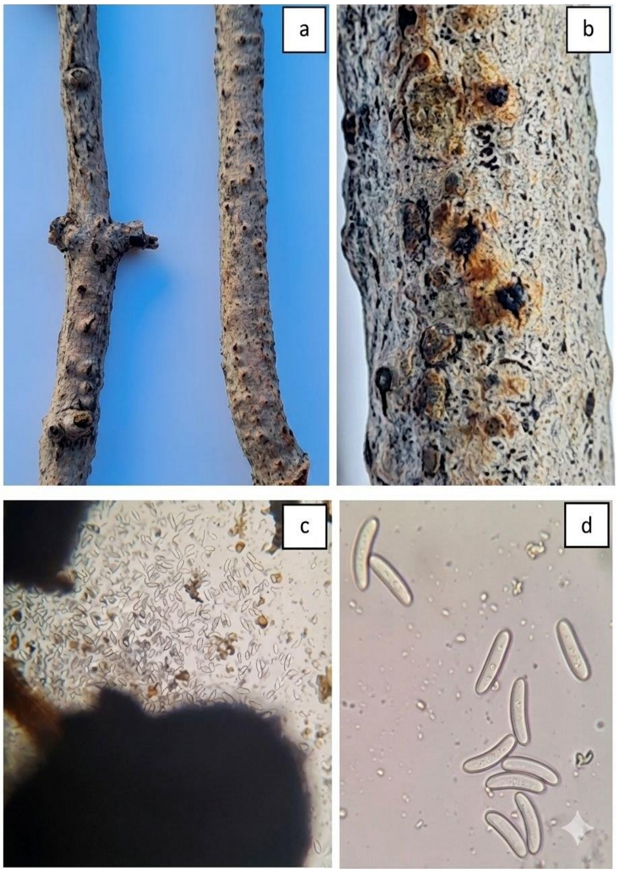

Figure 4. *Cytospora acericola* X.L. Fan & C.M. Tian: a. general view of affected branches, b. conidiomata, c. spores emerging from the conidioma, d. conidia.

Overall, the results of this study indicate a close interrelationship between morphological differentiation, ecological adaptation, and the evolution of reproductive specialization within the genus *Cytospora*. The composition of species in Uzbekistan suggests that they predominantly belong to the intermediate (A-II) and advanced (A-III) evolutionary stages of the genus.

According to Urban (1958), the morphological relationship between the sexual (teleomorphic) and asexual (anamorphic) forms in members of Valsaceae is interpreted through the structure of the stroma and its internal organization. In this framework, ascomata and conidiomata are formed on a common stromatic substrate, and their locus architecture demonstrates a high degree of correspondence. In particular, the classification of conidiomatal loci as simple or complex is associated with the distribution of ascomatal perithecia and the level of stromatal development. Urban further considers the stroma to be a primary taxonomic indicator, emphasizing that the parallel development of its internal (entostroma) and external (ectostroma)

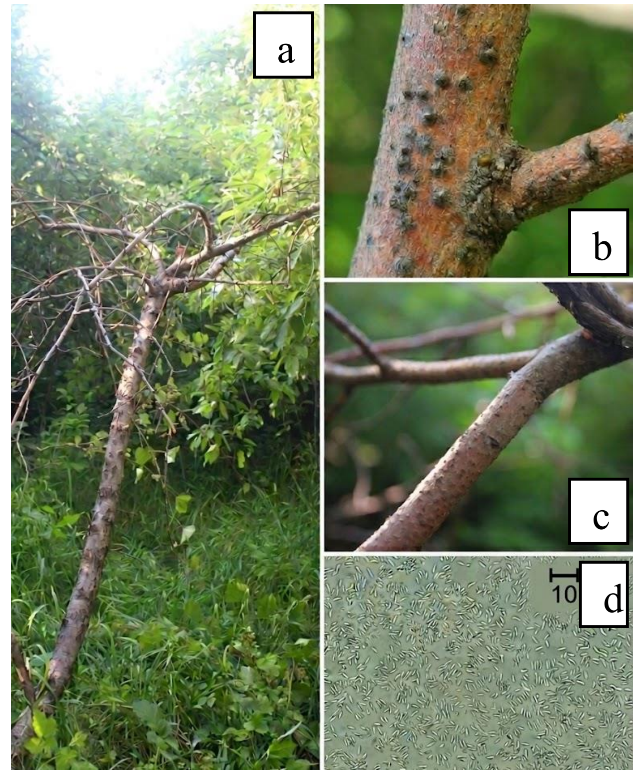

Figure 5. *Cytospora carphosperma* Fr.: a. *Malus domestica* (Suckow) Borkh., b, c. conidiomata and infected branch, d. conidia.

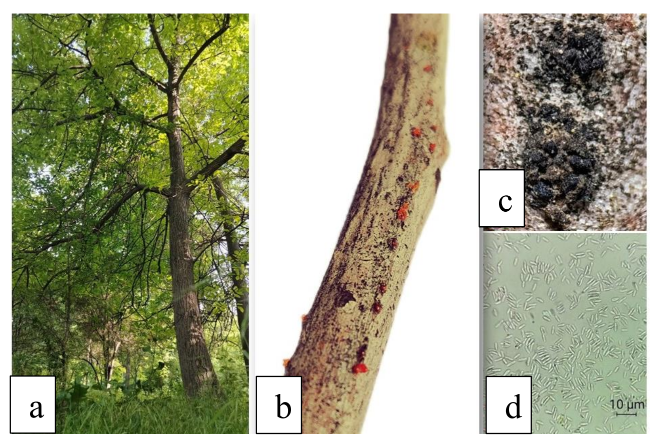

Figure 6. *Cytospora juglandenia* Sacc. a. general view of *Juglans regia* L. (Walnut tree), b. spore masses (cirri) emerging from the conidiomata, c. conidiomata on the tree bark, d. conidia.

components represents a key feature linking the sexual and asexual stages. On this basis, the anamorphic and teleomorphic forms are interpreted as components of a single, integrated biological system.

According to the findings of L. J. Spielman [1985], potential correlations exist between ascomatal stromatic architecture and conidiomatal loci, based on structural

Table 1. Groups and types of *Cytospora* species [Lin et al., 2024].

№	Fungal species	Host plant species	Groups and types (Lin et al., 2024)
1	*Cytospora ambiens* (Pers.) Sacc.	*Rubus* sp.	A-II group A9 type
2	*Cytospora aurora* Mont. & Fr.	*Salix olgae* Regel *Salix* sp. *Salix alba* L.	A-II group A7 type
3	*Cytospora capitate* Sacc. & Schulzer	*Malus domestica* (Suckow) Borkh. *Pyrus regelii* Rehder *Prunus persica* (L.)	A-II group A9 type
4	*Cytospora carphosperma* Fr.	*Malus domestica* (Suckow) Borkh. *Malus* sp. *Malus* sp.	A-II group A8 type
5	*Cytospora ceratophora* (Tul. & C. Tul.) Sacc.	*Prunus amygdalus* Batsch	A-II group A8 type
6	*Cytospora cercidicola* Henn.	*Cercis canadensis* L. *Populus alba* L. *Populus diversifolia* Schrenk. *Populus italica* (Ducoi) Moench.	A-II group A9 type
7	*Cytospora chrysosperma* (Pers.) Fr.	*Populus* sp. *Populus nigra f. italica* (Münchh.) A. Andersen *Populus nigra* L. *Populus pruniosa* Schernk. *Populus* sp.	A-II group A8 type
8	*Cytospora cydoniae* Schulzer.	*Elaeagnus angustifolia* L. *Elaeagnus songarica* (Bernh. ex Schltdl.) Schltdl.	A-II group A8 type
9	*Cytospora elaeagni* Allesch.	*Elaeagnus angustifolia* L. *Elaeagnus songarica* (Bernh. ex Schltdl.) Schltdl. *Elaeagnus orientalis* L *Elaeagnus orientalis* L	A-III group A13 type
10	*Cytospora eurotiae* Kravtzev.	*Ceratocarpus utriculosus* Bluket ex Krylov	A-III group A11 type
11	*Cytospora flavovirens* Sacc.	*Rosa webbiana* Wall. ex Royle	A-III group A13 type
12	*Cytospora fraxini* Delacr.	*Fraxinus excelsior* L.	A-III group A11 type
13	*Cytospora hippophaes* Thüm.	*Hippophae rhamnoides* L.	A-III group A11 type
14	*Cytospora horrida* Sacc.	*Betula pendula* subsp. *pendula*	A-II group A7 type
15	*Cytospora juglandina* Sacc. Mich.	*Juglans regia* L.	A-II group A8 type

congruence. In particular, the spatial organization and structural attributes of stromatic components show a notable correspondence between sexual and asexual morphs, thereby serving as a unifying morphological indicator that integrates these two developmental stages within a single systematic framework.

When comparing our findings with the conclusions presented by Z. Urban [1958] and L. J. Spielman [1985], both conceptual consistencies and differences become apparent. Specifically, both studies recognized the interrelationship between ascomatal and conidiomatal morphologies, emphasizing that such correlations are structurally congruent and bear significant evolutionary and functional relevance. The differences primarily emerge from the scope and focus of the methodological approaches adopted by the respective authors. Z. Urban [1958] and L. J. Spielman [1985] interpreted the correspondence between ascomatal and conidiomatal structures mainly as a methodological basis for taxonomic delineation and species identification. In

Table 1 (continues). Groups and types of *Cytospora* species [Lin et al., 2024].

№	1	2	3
16	*Cytospora leucostoma* (Pers.) Sacc.	*Acer semenovii* Fegel. *Cerasus mahaleb* Mill. *Crataegus turkestanica* Pojark. *Pistacia vera* L. *Prunus armeniaca* L. *Prunus avium* (L.) L. *Prunus persica* (L.) Batsch *Spiraea hypericifolia* L. *Ulmus campestris* Mill. *Ulmus chumlia* Melville & Heybroek	A-III group A11 type
17	*Cytospora lonicerae* Grov.	*Lonicera nummulariifolia* Jaub. & Spach	A-II group A7 type
18	*Cytospora microspora* Rabenh.	*Sorbus tianschanica* Rupr.	A-II group A9 type
19	*Cytospora pinastri* Fr.	*Pinus* sp.	A-II group A7 type
20	*Cytospora pruinosa* (Fr.) Sacc.	*Elaeagnus angustifolia* L.	A-II group A8 type
21	*Cytospora prunorum* Sacc.	*Padellus mahaleb* (L.) Vassilcz. *Persica vulgaris* Mill. *Prunus armeniaca* L. *Prunus domestica* L.	A-II group A7 type A-III group A11 type
22	*Cytospora punica* Sacc.	*Punica granatum* L.	A-III group A11 type
23	*Cytospora rosarum* Grev.	*Rosa* sp. *Rosa canina* L.	A-III group A12 type
24	*Cytospora rubescens* Fr.	*Prunus armeniaca* L. *Prunus cerasus* L. *Prunus persica* (L.) Batsch *Prunus spinosissima* (Bunge) Franch. *Prunus verrucosa* Franch. *Sorbus* sp.	A-II group A9 type
25	*Cytospora salicis* Rabenh.	*Salix alba* L. *Salix sangorica* L. *Salix songarica* Andersson	A-II group A6 type
26	*Cytospora schulzeri* Sacc. & P. Syd.	*Pyrus* sp.	A-II group A8 type
27	*Cytospora sophorae* Bres.	*Sophora japonica* L.	A-II group A8 type
28	*Cytospora terebinthi* Bres.	*Pistacia vera* L.	A-II group A8 type
29	*Cytospora translucens* Sacc.	*Salix babylonica* L.	A-II group A8 type
30	*Cytospora translucens* Sacc.	*Salix* sp. *Salix* sp.	A-II group A9 type
31	*Cytospora ulmi* Norphanphoun	*Ulmus* sp.	A-II group A9 type

contrast, our study approaches the issue from a broader evolutionary and ecological perspective. For instance, the absence of group A-I can be explained by the evolutionary reduction of simple, unilocular stromatic forms or their limited ecological significance. Groups A-II and A-III, on the other hand, reflect relatively advanced evolutionary stages. Thus, whereas the studies by Z. Urban [1958] and L. J. Spielman [1985] primarily illuminate the morphological spectrum, our approach reveals the evolutionary-ecological spectrum. Together, these three perspectives provide an integrative conceptual framework that addresses existing knowledge gaps within the genus *Cytospora*.

CONCLUSION

The predominance of the A-II and A-III morphotypes indicates that *Cytospora* species occurring in Uzbekistan occupy intermediate and advanced evolutionary stages.

In particular, the A-III group, characterized by fully differentiated locules, is regarded as the morphotype with the highest potential for producing sexual forms. Although sexual forms have not yet been observed, their absence does not necessarily indicate true nonexistence, but may reflect limitations in detection capabilities. This suggests that future ecological or experimental studies could potentially reveal the teleomorphic stages in these taxa. To further substantiate these conclusions, molecular-phylogenetic analyses are necessary, allowing verification of the evolutionary accuracy of the morphology-based classification and enabling the identification of cryptic species.

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Özbəkistanda *Cytospora* Ehrenb. növlərinin morfoloji differensasiyası və ekoloji uyğunlaşmasının təhlili

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Bu tədqiqat Lin və həmmüəllifləri tərəfindən təklif olunmuş müasir təsnifat sisteminə əsaslanaraq Özbəkistanda qeydə alınmış *Cytospora* cinsinə aid növlərin geniş təhlilini təqdim edir. Araşdırma nəticələri göstərir ki, A-II qrupuna aid nümayəndələr üstünlük təşkil edir və xüsusilə A8 və A9 tipləri daha geniş yayılmışdır. Bu tiplər daxili baxımdan mürəkkəb konidioma quruluşları ilə xarakterizə olunur; bunlara çoxkameralı sistemlər, mərkəzi sütunlar və rozetşəkilli konfiqurasiyalar daxildir. Belə mürəkkəb quruluşların çoxalma effektivliyini və sporların yayılmasını artırdığı ehtimal edilir. Bu struktur mürəkkəbliyi region üçün xarakterik olan quraq və kəskin kontinental iqlim şəraitində mühüm adaptiv üstünlüyü təmin edir. A-I qrupunun nümayəndələrinin olmaması sadə, təkkameralı stromatik formaların təkamül nəticəsində azalmasını və ya onların tədqiq olunan mühitdə ekoloji əhəmiyyətinin məhdud olmasını göstərə bilər. Bunun əksinə olaraq, A-II və A-III qrupları cinsin təkamül inkişafında daha irəliləmiş mərhələlər kimi qiymətləndirilə bilər və bu, artan morfoloji və funksional ixtisaslaşmaya keçidi əks

etdirir. A-III qrupuna aid tiplərin (A11–A13) nisbətən az rast gəlinməsi onların daha dar ekoloji amplitudaya malik olması ilə əlaqələndirilə bilər, çünki bu formalar struktur baxımından fərqli və tam bölünən lokul sistemlərinə malik olsalar da, daha spesifik ekoloji nişlərdə yaşayırlar. Nəticələr həmçinin qeyri-cinsi (anamorf) və cinsi (teleomorf) mərhələlər arasında güclü struktur və funksional uyğunluğu nümayiş etdirir. Xüsusilə, konidiomalardakı lokulların sayı, yerləşməsi və daxili diferensasiyası cinsi mərhələdəki peritesilərin təşkili ilə aydın paralellər nümayiş etdirir. A-II qrupunda müşahidə olunan çoxlokullu quruluşlar çoxsaylı peritesilərin formalaşması üçün inkişafın əsasını təşkil edə bilər, halbuki A-III tiplərindəki ayrı lokullar müstəqil təşkil olunmuş və ya qismən birləşmiş peritesial sistemlərə uyğun gəlir. Bundan əlavə, konseptakulabənzər strukturların (qara sərhəd xətləri) mövcudluğu mexaniki sabitlik və qorunmanı təmin edir və hər iki morf üçün mühüm taksonomik və funksional xüsusiyyət hesab olunur. Mövcud nəticələrin Z. Urban (1958) və L. J. Spielman (1985) tərəfindən irəli sürülmüş əvvəlki konsepsiyalarla müqayisəli qiymətləndirilməsi həm davamlılığı, həm də nəzəri genişlənməni ortaya qoyur. Əvvəlki tədqiqatlar askomatik və konidiomatik komponentlər arasındakı struktur uyğunluğun taksonomik əhəmiyyətini vurğuladığı halda, bu tədqiqat həmin yanaşmanı təkamül və ekoloji aspektlərlə genişləndirir. Xüsusilə göstərilir ki, cins daxilində morfoloji müxtəlifləşmə adaptiv strategiyalar və reproduktiv ixtisaslaşma ilə sıx bağlıdır. Ümumilikdə, Özbəkistanda *Cytospora* növlərinin tərkibi orta inkişaf etmiş (A-II) və daha irəliləmiş (A-III) təkamül formalarının üstünlük təşkil etdiyini göstərir. Bu isə morfoloji differensasiya, ekoloji uyğunlaşma və reproduktiv sistemlərin təkamülü arasında sıx qarşılıqlı əlaqəni vurğulayır. Bu nəticələr cins haqqında daha inteqrativ anlayışın formalaşmasına töhfə verir və taksonomik, morfoloji və təkamül baxışları arasındakı boşluqları aradan qaldırmağa kömək edir.
Açar sözlər: *anamorf və teleomorf mərhələlər, arid iqlim uyğunlaşması, konidiomatik quruluş, göbələklərin reproduktiv strategiyaları, lokul differensasiyası, mikromiset müxtəlifliyi, peritesial yerləşmə, stromatik təşkilatlanma*

Анализ морфологической дифференциации и экологической адаптации видов *Cytospora* Ehrenb. в Узбекистане

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Данное исследование представляет комплексную оценку видов рода *Cytospora*, зарегистрированных в Узбекистане, на основе современной классификационной системы, предложенной Lin и соавторами. Анализ выявил явное преобладание представителей группы A-II, среди которых особенно широко распространены типы A8 и A9. Эти типы характеризуются внутренне сложными конидиоматозными структурами, включая многокамерные образования, центральные колонны и розетковидные конфигурации, которые, по-видимому, повышают эффективность размножения и распространения спор. Такая структурная сложность, вероятно, обеспечивает значительное адаптивное преимущество в условиях засушливого и резко континентального климата, характерного для региона. Отсутствие представителей группы A-I может свидетельствовать либо об эволюционной редукции простых однокамерных строматических форм, либо об их ограниченной экологической значимости в исследуемой среде. Напротив, группы A-II и A-III можно рассматривать как относительно более продвинутые стадии эволюционного развития рода, отражающие переход к возрастающей морфологической и функциональной специализации. Сравнительно низкая встречаемость типов группы A-III (A11–A13), вероятно, связана с их более узкой экологической амплитудой, поскольку эти формы, несмотря на структурно дифференцированные и полностью разделённые локулярные системы, занимают более специализированные экологические ниши. Результаты также демонстрируют тесное структурное и функциональное соответствие между бесполыми (анаморфными) и половыми (теломорфными) стадиями. В частности, количество, расположение и внутренняя дифференциация локул в конидиомах имеют чёткие параллели с организацией перитециев в половой стадии. Многолокулярные конфигурации, наблюдаемые в группе A-II, могут служить основой для формирования множества

перитециев, тогда как отдельные локулы типов A-III соответствуют независимо организованным или частично сросшимся перитециальным системам. Дополнительные признаки, такие как наличие концептакулоподобных структур (чёрных пограничных линий), обеспечивают механическую устойчивость и защиту, а также представляют важные таксономические и функциональные характеристики обеих морф. Сравнительная оценка полученных результатов с более ранними концепциями, предложенными Urban (1958) и Spielman (1985), показывает как преемственность, так и концептуальное расширение. Если предыдущие исследования подчеркивали таксономическое значение структурного соответствия между аскоматозными и конидиоматозными компонентами, то настоящая работа расширяет данную интерпретацию, интегрируя эволюционные и экологические аспекты. В частности, показано, что морфологическая диверсификация внутри рода тесно связана с адаптивными стратегиями и репродуктивной специализацией. В целом, видовой состав *Cytospora* в Узбекистане отражает преобладание промежуточных (A-II) и более продвинутых (A-III) эволюционных форм, что подчёркивает тесную взаимосвязь между морфологической дифференциацией, экологической адаптацией и эволюцией репродуктивных систем. Эти результаты способствуют более интегративному пониманию рода и помогают устранить пробелы между таксономическими, морфологическими и эволюционными подходами.
Ключевые слова: *анаморфные и теломорфные стадии, адаптация к засушливому климату, конидиоматозная структура, репродуктивные стратегии грибов, дифференциация локул, разнообразие микромицетов, расположение перитециев, строматическая организация*