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Documentation of Xylariales Fungal Diversity in Navsari District, Gujarat, India

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ABSTRACT

The order Xylariales is a diverse group of fungi with significant ecological, medical, and biotechnological relevance. This study documents the diversity of Xylariales from Navsari District, Gujarat, India, an area previously underexplored for fungal biodiversity. Field surveys conducted during the monsoon seasons from 2022 to 2024 revealed 12 species belonging to the families Hypoxylaceae and Xylariaceae, with notable species such as *Xylaria castorea*, *X. culleniae*, and *X. poitei* newly recorded for the region. The survey involved detailed morphological and microscopic examination of specimens collected from various habitats, including decaying wood, fallen branches, and soil. This study contributes to the understanding of fungal diversity in Gujarat and highlights the need for further research to explore the full range of fungal species in the state's forested regions, where biodiversity remains underrepresented. Additionally, the findings offer valuable insights into the ecological roles and potential biotechnological applications of Xylariales fungi.

Keywords: Xylariales, Fungal diversity, Taxonomy, Navsari District.

INTRODUCTION

Xylariales is a significant and diverse order of fungi belonging to the class Sordariomycetes, which includes various species with ecological, medical, and biotechnological importance. This order is mainly recognized for its saprobic, endophytic, and pathogenic species, which contribute to wood decay, plant health, and the production of secondary metabolites with potential pharmacological applications. The order includes several families, such as Xylariaceae, Diatrypaceae, Hypoxylaceae, and Amphisphaeriaceae, characterized by the formation of perithecial ascomata, a key morphological trait that defines many species within Xylariales (Smith *et al*., 2003; Wendt *et al*., 2018). The Xylariaceae fungi are well-known for their large fruiting bodies, long-lasting presence in nature, visibility to the naked eye, and resilience to seasonal changes. Initially, these fungi were grouped into two informal subfamilies, Xylarioideae and Hypoxyloideae, based on their asexual morphology, particularly the *Geniculosporium* and *Nodulisporium*-like conidiophores. These two subfamilies were considered the major clades within the Xylariaceae family (Maharachchikumbura *et al*., 2016).

Over 85 genera and 1300 species are estimated within the family (Zhang *et al*., 2006; Li *et al*., 2015), with the utmost representative diversity in the tropics (Rogers 2000). They are mostly saprophytic, may be pathogenic (Proffer 1988; Hartman *et al*., 2008), and endophytic in nature and appear to exist on decayed wood, dung, litter, and soil (Davis *et al*., 2003; Okane *et al*., 2008). Certain species are host-specific; an extensive range of different genera of different fungal groups are associated with bamboo and palm species (Suwannasai 2013) and even with teak trees. However, later multigene phylogenetic analyses revealed that they belong to separate clades, leading to their reclassification as two distinct families: Hypoxylaceae and Xylariaceae (Wendt *et al*., 2018). Molecular clock data placed Hypoxylaceae within the Xylariales order, which includes 18 genera (Daranagama *et al*., 2018). More recently, Hyde *et al*. (2020) described the Xylariaceae fungi group with 51 different genera across two distinct families, acknowledging 19 genera for Hypoxylaceae and 32 genera in the new Xylariaceae family. Moreover, the biotechnological and pharmacological potential of these fungi attracted the attention of the researchers.

Beneficiary to the record, the present study contributes 12 species of order Xylariales belonging to two family Hypoxylaceae and Xylariaceae with two genera viz. Daldinia (2 species) and Xylaria (10 species), among which *Xylaria castorea, X. culleniae* and *X. poitei* are newfangled in the Navsari district

and Gujarat state records. Due to a lack of information and studies on fungal diversity in the Gujarat state, it is difficult to establish the exact number of species in all mentioned genera of Xylariaceae and their distribution in the state. The main aim of the present study is to document the diversity status of Xylariales from the Navsari District, Gujarat state, India.

MATERIALS AND METHODS

Study area

Navsari district is situated on the Arabian coastline at the southern border of Gujarat state. Navsari district is situated between 20.07° and 21.00° North Latitude and 72.43° and 73.00° East Longitude. The geographical area of the district is 2196 sq. km. Navsari district has a hot and humid climate, falling under a heavy rainfall agroclimatic zone, with maximum temperatures ranging from 35°C to 41°C. The data reached an all-time high of 199.200 mm in 15 Jul 2022 and a record low of 0.000 mm in 20 Mar 2025. The Tropical Dry Deciduous Forests cover a total area of 290 sq. km, which constitutes 13.09% of the geographical area.

Collection and identification

All the species were collected during the monsoon seasons of 2022–2024 during several trips to various localities. Healthy specimens at different stages of development were collected. Field photographs were taken to note colour, size, shape, and habitat, whereas other ecological characteristics were noted down in the field notebook. Microscopic observations of fresh fruiting bodies were done using 1.5% Phloxine B stain and a Lawrence and Mayo N-300M research microscope. Dry and wet (70% ethanol) preservation techniques have been used for collected specimens. All specimens were examined for their morphological characters and identified with the help of available literature (Martin 1970; Thind & Waraitch 1969, Thind & Dargan 1975, 1978, 1979, Dargan 1980).

RESULTS

An intensive survey in the Navsari district of Gujarat, including hilly regions, plains of different climatic regimes, and agricultural lands, was carried out from 2022–2024. From the total collection, 12 species out of 105 species were found to be of order Xylariales, belonging to family Hypoxylaceae and Xylariaceae. The detailed morphological characteristics are:

Daldinia concentrica (Bolton) Ces. & De Not. 1863

Stromata spherical, sessile or sub-sessile, smooth, hard, solitary, 3–8 cm in diameter × 2–4 cm high, purple-brown which turns to black and gets pimpled with maturity. Cracks appear on the surface, revealing reddish-brown granules beneath. The flesh is arranged in concentric zones/layers, and each zone is representative of the seasonal growth, and hence the name is given as concentrica. Perithecia are tubular to lanceolate, 1–2 mm in length × 0.2–0.5 mm in diameter, with a slightly papillate ostiole. Asci are cylindrical and 200–250 µm in length × 8–10 µm in width. Ascospores dark brown, elliptical to fusiform, unicellular, rounded ends, 6–8 × 12–17 µm in size with straight germ slit spore length on more convex side.

Habitat: Dead and decaying wood, fallen beech.

Materials examined: India- Gujarat. Navsari. Vansda. Mankunia; 20.664925°N, 73.391157°E; 20.VIII. 2023; JM Patel and DS Patel, obs.; Forest; Voucher number NVR - 53.

Daldinia childiae J.D. Rogers & Y.M. Ju, 1999

Stromata depressed spherical or sub-globose, solitary, sessile or with short and stout stipe, extended to a flattened apex. The size of stroma 5–15 mm in width × 6–13 mm in length. The surface is smooth and dark brown, which becomes dark black with maturity, orange-brown granules can also be seen beneath the surface. Perithecia monostichous tubular, 1–2 × 0.2–0.5 mm in diameter with umbilicate ostiole. Asci cylindrical but appears too old. Ascospores brown to dark brown, unicellular, ellipsoid-inequilateral, with rounded ends, 11–16 × 5–8 µm, with straight germ slit spore-length on convex side.

Habitat: Dead and decaying wood.

Materials examined: India- Gujarat. Navsari. Vansda. Sadad Devi; 20.761886°N 73.475237°E; 07.VII. 2023; JM Patel and DS Patel, obs.; Forest; Voucher number NVR - 32.

***Xylaria apiculata* Cooke 1879**

Stromata gregarious, occasionally fasciculate to solitary and scattered, slender, upright, stipitate, often unbranched, and long, ranging from 1–6 cm in height × 1–3 mm across. The surface is dark black, with raised lines and dense, black stipe. The fertile portion of the stromata is sub-apical, cylindrical in section, and rounded or apiculate at the apex. Perithecia are prominent, completely immersed, globose, and 0.2–0.6 mm in diameter. Asci are cylindrical with mono-serrate 8 spores, 229–280 µm length × 7–9 µm width. Ascospores are brown, unicellular, ellipsoid with rounded ends, and 7–12 × 20–28 µm in size.

Habitat: Dead wood, twigs.

Materials examined: India- Gujarat. Navsari. Vansda. Sara; 20.797831°N 73.411567°E; 29.VII.2024; JM Patel and DS Patel, obs.; Forest; Voucher number NVR - 92.

***Xylaria castorea* Berk. Hooker. 1855**

Stromata solitary to gregarious but not fasciculate; unbranched, cylindrical, clavate, lanceolate or broadly spathulate, (1–)3–4(–6) cm long × 3–25 mm wide × 2–5 (–10) mm thick, tip acute to rounded, entire stroma fertile; sessile or seated on a barely differentiated, plane or slightly enlarged, glabrous or villous stipe to 7 mm long × 3–4 mm wide; brown to dull blackish brown. Surface splitting into distinct plates, each plate with 1–2 minute papillae; perithecia completely immersed, 400–500 µm diam. Asci 130–140 µm total length × (5.0–)5.5–7.0(–8.0) µm, sporiferous portion (50–)70–85(–95) µm, cylindrical; apical ring J+, minute, 2–3 µm wide × 1–2.5 µm high; 8-spored, ascospores uniseriate with overlapping ends.

Habitat: Soil, dead wood.

Materials examined: India- Gujarat. Vansda. Kharjai; 20.798854°N 73.435818°E; 18.VIII.2022; JM Patel and DS Patel, obs.; Forest; Voucher number NVR - 26.

***Xylaria culleniae* Berk. & Broome, 1873**

Fruiting bodies are erect, elongated black branches, whitened from midway to tips. The hairs of the stem are septate. The ascospores of *X. culleniae* are relatively smaller, and the stomata are generally less robust. Spore dimensions are 8.5–9.5 × 3.5–4.5 µm. Sporidia 0.016 × 0.005–0.006 mm. The colour of the spores are brown and are ellipsoid or inequilateral in shape. Germ slit is straight and long. The length of stroma is up to 7 cm. Stromata unbranched or branched, cylindrical, long conical. Texture soft. Perithecia 0.1–0.3 mm diam. Ostioles minutely papillate.

Habitat: Dead roots, wood.

Materials examined: India- Gujarat. Navsari. Umra; 20.878895°N 73.241986°E; 12.VIII.2023; JM Patel and DS Patel, obs.; Forest; Voucher number NVR - 62.

***Xylaria feejeensis* (Berk.) Fr.1851**

Stromata erect, more or less cylindrical, branched or unbranched, flattened to bulky, short, and with well-defined, distinct curved tips, 4–5 cm long × 5 mm wide. Stromata surface rough, hard, and non-hairy. Stalks are short, black in colour externally, and up to 5 cm in length. Perithecia are globose and 247–338 µm × 195–260 µm with small papillate ostioles, asci long, brown and 80–85 µm length × 3–6 µm width. Ascospores light brown to dark brown, elliptical and 4–5 × 8–10 µm in size.

Habitat: Fallen leaves and twigs.

Materials examined: India- Gujarat. Vansda. Kelia; 20.693890°N 73.277678°E; 09.XI.2022; JM Patel and DS Patel, obs.; Forest; Voucher number NVR - 07.

***Xylaria filiformis* (Alb. & Schwein.) Fr. 1849**

Stromata simple, long, slender, solitary, scattered, and branched, 4–10 cm long × 2 mm wide, filiform and black smooth-surfaced, which become wrinkled at maturity. The stalk is long and smooth with a fertile tip that is very thin, distinct, slightly undulating and light brown in colour. Flesh pale to white, tough, and solid. Perithecia solitary, intercalary, black to brown in color, rough surface, 4–8 mm diameter with papillate ostioles. Asci are cylindrical, 130–150 × 5–6 µm in length and width, respectively. Ascospores are black, uniseriate with overlapping ends, and 4-6 × 10-13 µm in size, inequilateral with one flat to concave side and the other round side.

Habitat: Decaying leaves, Twigs, stems, and wood.

Materials examined: India- Gujarat. Gandevi. Sonvadi; 20.853665°N 72.983266°E; 26.VII.2024;

JM Patel and DS Patel, obs.; Forest; Voucher number NVR - 84.

***Xylaria hypoxylon* (L.) Grev. 1824**

Stromata slender, sub-cylindrical to strap-shaped, solitary or gregarious, black below and powdery white above, reaching up to 8 cm tall. Perithecia completely immersed or nearly superficial, surface of the fertile portion is tuberculate with longitudinal splitting and 0.2–0.4 mm in size. Asci cylindrical, 8-spored, 100 µm in length × 7–8 µm in width, ascospores black, uniseriate, smooth, slightly bean-shaped, 4.5–6 × 11.4–12.4 µm, un-equilateral with one side and rounded other side.

Habitat: Decaying wood, fallen branches, and rotting stumps of broad-leaved trees.

Materials examined: India- Gujarat. Vansda. Vangan; 20.694362°N 73.426689°E; 15.VIII.2023; JM Patel and DS Patel, obs.; Forest; Voucher number NVR - 71.

***Xylaria longipes* Nitschke 1867**

Stromata single or in-group, club-shaped, tough, 3–8 cm in length × 0.2–2 cm in diameter, and lengthened to a round apex. The surface is grey to brownish and turns black; cracky and scaly with age. Perithecia 0.5–1 mm in diameter with papillate ostiole, asci long-stipitate, 120–200 µm in length × 6–8 µm in diameter. Ascospores brown to black, smooth, fusiform-shaped with a slit that runs throughout the spore, and 4–7 × 12–15 µm.

Habitat: Soil, stumps, buried hardwoods.

Materials examined: India- Gujarat. Chikhli. Soldhara; 20.714357°N 73.072795°E; 27.VII.2023; JM Patel and DS Patel, obs.; Forest; Voucher number NVR - 44.

***Xylaria nigripes* (Klotzsch) Cooke 1883**

Stromata cylindrical, long, branched or unbranched, 4–8 cm in length × 0.2–0.5 cm in width, and extended fertile apex, which is curved and pale yellow in color. It turns to dark black with maturity and also becomes tough with age. The surface is smooth and becomes wrinkled when fully grown. Perithecia are arranged very compactly and almost embedded, black, and 0.1–0.3 mm in diameter. Asci are cylindrical, long, 60–80 µm in length × 2–4 µm in width. Ascospores are little flattened, ellipsoid-inequilateral, smooth surfaced, brown in colour and 2–3 × 4–5 µm in diameter with germ slits that run the full length of the spore.

Habitat: Soil, dead wood, leaf litter, dung.

Materials examined: India- Gujarat. Vansda. Kala Amba; 20.798217°N 73.457828°E; 13.XI.2022; JM Patel and DS Patel, obs.; Forest; Voucher number NVR - 18.

***Xylaria polymorpha* (Pers.) Grev., 1824**

The fruiting body commonly grows on the decaying wood near the base. Stromata 3–20 cm long and 2–5 cm across, occurring alone or in clusters, club- or finger-shaped, occasionally flattened, and tough. Stalk short, cylindrical, and black in coloured. Surface rough and wrinkled at maturity. The tip of the fruiting body is rounded and white in colour when young and turns to black eventually with age. Perithecia black, sub-spherical, and 0.2–1 mm in diameter. Asci cylindrical, stipitate, long, 150–210 µm in length × 7–15 µm in width. Ascospores are smooth, fusiform with straight slits extending up to half or up to two-thirds of the spore's length, 5–10 × 20–30 µm in size.

Habitat: Stumps, deadwood, broadleaved trees.

Materials examined: India- Gujarat. Vansda. Khambhala; 20.755511°N 73.467441°E; 10.XI.2023; JM Patel and DS Patel, obs.; Forest; Voucher number NVR - 80.

***Xylaria poitei* (Lév.) Fr. 1851**

stromata, 4–6 × 16–25 cm, with several arising from a common source, unbranched, with rounded apices, stromatal surface smooth, blackish, with black ostioles, interior white, becoming hollow; perithecia monostichous; asci 8-spored, long-stipitate; ascospores one-celled, ellipsoid, 15.6–18.2 × 5.2–7.8 µm, dark brown, bi-guttulate with indistinct germ slit.

Habitat: Tree, decaying wood.

Materials examined: India- Gujarat. Vansda. Waghai; 20.757755°N 73.481233°E; 02.XI.2023; JM Patel and DS Patel, obs.; Forest; Voucher number NVR - 82.



Figure 1: Fruting body of A to L specimens. A, *Daldinia concentrica;* B, *Daldinia childiae;* C, *Xylaria apiculate;* D, *Xylaria castorea;* E, *Xylaria culleniae;* F, *Xylaria feejeensis;* G, *Xylaria filiformis;* H, *Xylaria hypoxylon;* I, *Xylaria longipes;* J, *Xylaria nigripes;* K, *Xylaria polymorpha;* L, *Xylaria poitei.* Scale bar A=1 cm; B=2 cm; C=1.64 cm; D=0.85cm; E=1.5 cm; F=2 cm; G=2.5 cm; H=1.20 cm; I=2 cm; J=1.5 cm; K=2.5 cm; L=1cm.

DISCUSSIONS

This study highlights the significant diversity of Xylariales fungi in the Navsari district of Gujarat, contributing new records and ecological insights into the fungal species of the region. The order Xylariales, part of the class Sordariomycetes, includes fungi that play vital roles in ecosystem functioning, particularly in decomposing organic matter and nutrient cycling. Through an extensive survey over the monsoon seasons of 2022-2024, twelve species were identified, belonging to two families: Hypoxylaceae and Xylariaceae. Few studies on fungal diversity of Gujarat have been carried out earlier (Arya, 2004; Arya *et al*., 2008; Nagdesi and Arya, 2012; Nagdesi and Arya, 2013; Rajput *et al*., 2015). *Daldinia concentrica* and *Daldinia childiae* have been described by (Korat *et al*.,2013; Rajput *et al*., 2015; Koyani *et al*., 2016; Nagadesi and Arya 2017). *Xylaria apiculate, X. feejeensis, X. filiformis, X. hypoxylon, X. longipes, X. nigripes, X. Polymorpha* have already been documented in our previous study. Among these, *Xylaria castorea*, *Xylaria culleniae*, and *Xylaria poitei* were new records for both the Navsari district and Gujarat state, enriching the known fungal biodiversity of the area. The findings reaffirm the importance of further mycological exploration, especially in tropical dry deciduous forests like those in Gujarat, where species diversity might be underreported. The varied climatic conditions in Navsari, which experiences high rainfall during the monsoon and dry spells in the winter, likely influence fungal distribution, making it important to consider seasonal factors when studying fungal populations.

CONCLUSION

Conclusively, the current study is a preliminary but very essential contribution to the fungal diversity of Gujarat state, and further studies are recommended to document the fungal diversity of the state. The state of Gujarat is never explored for fungal diversity. The discovery of these fungi in Navsari opens opportunities for further research into their biotechnological potential, especially in the context of drug discovery and other commercial applications. Available literature indicates that most of the studies on fungal diversity in Gujarat state are either from plant or human pathogens, while forest areas were never studied earlier (Rajput *et al*., 2015). More species are expected from the family and therefore, further studies are warranted to investigate the diversity of fungi occurring within the state in conclusion, this study provides important insights into the fungal diversity of the Navsari district, Gujarat, contributing valuable information to the field of mycology. It highlights the ecological importance of Xylariales fungi and recommends continued research into their roles in forest ecosystems and their potential applications in biotechnology.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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