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Xylariaceae: Overview and addition to fungal diversity of Gujarat state

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Abstract

Extensive fieldwork in all 33 districts including different forests of Gujarat state during 2007 to 2014 resulted in the collection of 349 fungal taxa. Among them, 19 species represented the family Xylariaceae belonging to three genera *viz*. *Daldinia* (3 species), *Hypoxylon* (2 species) and *Xylaria* (14 species). From these species, *Daldinia concentrica, D. eschscholtzii*, *Hypoxylon begae*, *Xylaria curta*, *X. feejeensis*, *X. polymorpha* and *X. regalis* are reported previously, while *Daldinia childiae*, *Hypoxylon rickii*, *Xylaria apiculata*, *X. carpophila*, *X. cubensis*, *X. filiformis*, *X. gigentea*, *X. hypoxylon*, *X. longipes*, *X. nigripes*, *X. primorskensis* and *X. psidii* are recorded for the first time from Gujarat. All the species are saprobic except *Hypoxylon fragiforme* and *Xylaria polymorpha*, which are exclusively observed on the bark of *Bombax ceiba* and *Lannea coromandelica* as well as dead trees. The distribution, habitat, morphology of the identified species are described in this article.

Key words – Biodiversity – mycobiota – species list – taxonomy – Xylariaceae

Introduction

Xylariaceae is generally recognized as one of the most diverse and largest families of Ascomycota and widely distributed throughout the world evidenced by reports from different regions with broad ecological diversity (Lee et al. 2002). 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 tropics (Rogers 2000). They are mostly saprophytic, may be pathogenic (Proffer 1988; Hartman et al. 2008) and endophytic in nature and appeared to exist on decayed wood, dung, litter, soil (Davis et al 2003; Okane te al 2008). Certain species are host specific; an extensive range from different genera of different fungal groups that are associated with bamboo and palm species (Suwannasai 2013) and even with teak trees. Moreover biotechnological and pharmacological potential of these fungi dragged attention of the researchers.

Xylaria Hill ex Schrank (1789) is the largest genus of the family Xylariaceae comprised of more than 500 species (Hsieh et al. 2010). Contribution to Indian Xylariaceae diversity was represented well by Thind & Waraitch (1969), Thind & Dargan (1975, 1978, 1979), Rajulu et al. (2013), where this genus appeared more prominent than both the genera *Daldinia* and *Hypoxylon*. Kshirsagar et al. (2009), Ramesh et al. (2012) and Hande & Hiwarale (2013) reported more than 10 *Xylaria* species in western and northern states of India. However, existing awareness of these fungi

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in Gujarat state (India) is at their primary stage with only few reports (Korat et al. 2013, Nagadeshi & Arya 2014, Rajput et al. 2015).

State of Gujarat is known to possess varying climatic conditions such as moist deciduous (ending part of Western Ghat) to extreme desert conditions (Rann of Kutchh), Savanna type grassland and arid to semiarid conditions in northern part of the state. It has longest seacoast in country and shares unique diversity of different plant groups. Documentation of angiosperm flora of Gujarat though studied thoroughly but mycoflora has always been neglected by the botanists (Rajput et al. 2015). Recently, few sporadic reports on fungal diversity of Gujarat may be found in the literature but they are only restricted to pathogenic fungi related to agricultural crops or human beings (Bhavsar et al. 2012, Assudani 2013, Dhingani et al. 2013, Nagdesi & Arya 2014). In the present study we attempted to document the diversity of Xylariaceae, which is a rich source of various secondary metabolites due to endophytic nature of many species (Hacioglu et al. 2011, Nilza 2013, Fan et al. 2014). It is also valued for various lignocellulosic enzymes that have a wide application in pharmaceutical, paper and pulp industry, in textile industry etc. (Soto et al. 2015).

Beneficiary to the record, the present study contributes 19 species of Xylariaceae belonging to three genera *viz*. *Daldinia* (3 species), *Hypoxylon* (2 species) and *Xylaria* (14 species), among which *Daldinia childiae*, *Hypoxylon rickii*, *Xylaria apiculata*, *X. carpophila*, *X. cubensis*, *X. filiformis*, *X. gigentea*, *X. hypoxylon*, *X. longipes*, *X. nigripes*, *X. primorskensis* and *X. psidii* are newfangled to Gujarat record. Due to lack of information and studies on fungal diversity of the Gujarat state, it is difficult to establish the exact number of species in all three mentioned genera of Xylariaceae and their distribution in the state. The main aim of the present study is to document the diversity status of Xylariaceae from the Gujarat state (India).

Materials & Methods

Extensive fieldwork was carried out in different forest regions with various climatic regimes like moist deciduous forest, dry deciduous forest, scrub forest, wet lands, arid and semi-arid regions in all 33 districts of the Gujarat state during 2007 to 2014. From the total collection 19 species from the family Xylariaceae were reported. The fruiting bodies of all the fungal strains were kept in the sterile polyethylene bags labeled with the location, name of the host substrate and date of collection and carried to the laboratory. All the fruiting bodies were micro-photographed using Canon SLR camera in field conditions and then in laboratory by using Leica Stereo zoom and Leica DME 2000 trinocular photomicroscope. 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).

For further confirmation, samples with doubtful identity were also processed for molecular identification. Collected fruiting bodies were inoculated on Potato Dextrose Agar and Malt Extract Agar media, and pure cultures were established by serial transfer technique and exploited for DNA extraction by using Plant/Fungi DNA isolation kit (Sigma Cat# E5038) as suggested by the manufacturer and manually by CTAB method described by Plaza et al. (2004). PCR was carried out using 1X final concentration of Ready Mix™ Taq PCR Reaction Mix (Sigma) and template DNA (50 ng/µl). Amplification of DNA was performed with the help of Thermal cycler (Applied BiosystemsVeriti®) and the primers ITS 1 and ITS 4 as described by White et al. (1990). The amplified products were purified using Purelink™ Quick PCR Purification kit (Cat# K310001) and successfully obtained PCR purified products were sent for sequencing to Eurrofins Genomics India Pvt. Ltd., Bangalore. Sequence data obtained after sequencing was subjected to sequence match analysis using Basic Local Alignment Search Tool (BLAST) on NCBI for identification of species. Identification of species was done by 99% base-pair match of the sequence obtained to the closest available reference sequences.

Results

An intensive survey in all 33 districts of Gujarat including hilly regions, plains of different climatic regimes and agricultural lands was carried out from 2007─2015. From the total collection

nineteen species were found to be of Xylariaceae. The detail morphological characteristics are:

Daldinia concentrica (Bolton) Ces. & De Not, Commentario della Società Crittogamologica Italiana 1 (4): 197 (1863). Fig. 1A

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 got pimpled with maturity. Surface gets cracked and reddish brown granules can be seen under the surface. 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, 1–2mm length × 0.2–0.5 mm diameter with 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.

Materials examined – Ahawa, Junagadh, Pavagadh, Polo forest, Ratanmahal, Sagai forest (Gujarat), host: unidentified wood log, collectors: Dr. RD Koyani and Dr. KS Rajput, date: August 2013, July 2014, August 2014, September 2014, code#: KSR0034

Daldinia childiae J.D. Rogers & Y.M. Ju, in Rogers, Ju, Watling & Whalley, Mycotaxon 72: 512 (1999). Fig. 1B

Stromata depressed spherical or sub-globose, solitary, sessile or with short and stout stipe, extended to a flattened apex. The size of stroma ranges 5–15 mm width × 6–13 mm 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 at too old age. 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.

Materials examined – Panchmahal, Dang, Junagadh forests; host: on decaying wood logs, in moist places in forest areas and timber depot (Gujarat), collectors: Dr. RD Koyani and Dr. KS Rajput, date: July 2014, August 2014, code#: KSR0121

Daldinia eschscholtzii (Ehrenb.) Rehm, Annales Mycologici 2 (2): 175 (1904).

Stromatal shape is highly variable ranging from hemispherical to placentiform, turbinate to stipate, sessile, solitary, short stout, and smooth. Their size ranges 2–6 cm across and 2–3 cm high with brown to black surface and gets varnished with age, and granules appear with maturity. Perithecia are tubular, 0.8–1.8 mm length × 0.3–0.5 mm diameter, composed of conspicuous internal zones of light and dark concentric rings which are dark red to brown in color. Asci with amyloid ring, 150–250 µm length × 7–10 µm width. Ascospores are brown to dark brown, unicellular, ellipsoid-inequilateral, with rounded ends, 10–12 × 5–6 µm, with straight germ slit spore-length on convex side.

Materials examined – Junagadh, Polo forest, Saputara, Dangs, Vadodara, Ratanmahal, host: unknown wood logs in moist areas in forest, collectors: Dr. RD Koyani and Dr. KS Rajput, date: August 2013, July 2014, August 2014, September 2014, code#: KSR0049

Hypoxylon begae Y.M. Ju & J.D. Rogers, Mycologia Memoirs 20: 91 (1996).

Stromata spherical to hemispherical, uniform with perithecial mounds, 0.6–3.5 cm in diameter with brown to black layers, hard, and dark brown granules can be seen immediately beneath the surface, which is 2–8 mm thick. Surface brown and turns dark with age. Perithecia are tubular, 0.6–1mm length × 0.2–0.5 mm diameter. Asci are discoid, 495–520 mm total length × 15–17 mm broad. Ascospores brown to black, unicellular, ellipsoid, nearly equilateral, with broadly rounded ends, spores measuring 20–30 × 12–15 µm in size.

Materials examined – Junagadh, Dang forest, Panchmahal, Sagai and Polo forest, host: dead and degraded unknown wood logs, collectors: Dr. RD Koyani and Dr. KS Rajput, date: August 2013, August 2014, September 2014, October 2014, code#: KSR0028

Hypoxylon rickii Y.M. Ju & J.D. Rogers, Mycologia Memoirs 20: 174 (1996).

Stromata flattened, plane, almost pulvinate, 0.6–2 mm diameter. Surface rusty to orange red colored. Perithecia tubular, 0.5–1 mm length × 0.2–0.6 mm width and granules can be seen immediately beneath the surface, 0.2–1 mm in thickness. Asci 100–150 µm × 4–6 µm in length and width respectively. Ascospores brown, unicellular, ellipsoid-inequilateral with rounded ends and possess slightly sigmoid germ slit throughout the spore-length and 3–4 × 6.5–8 µm in size.

Materials examined – Ratanmahal, Polo forest, Jessor, Girnar, Chotaudepur, host: *Pongamoea pinnata* and other unknown wood logs, collectors: Dr. RD Koyani and Dr. KS Rajput, date: August 2013, August 2014, code#: KSR0026

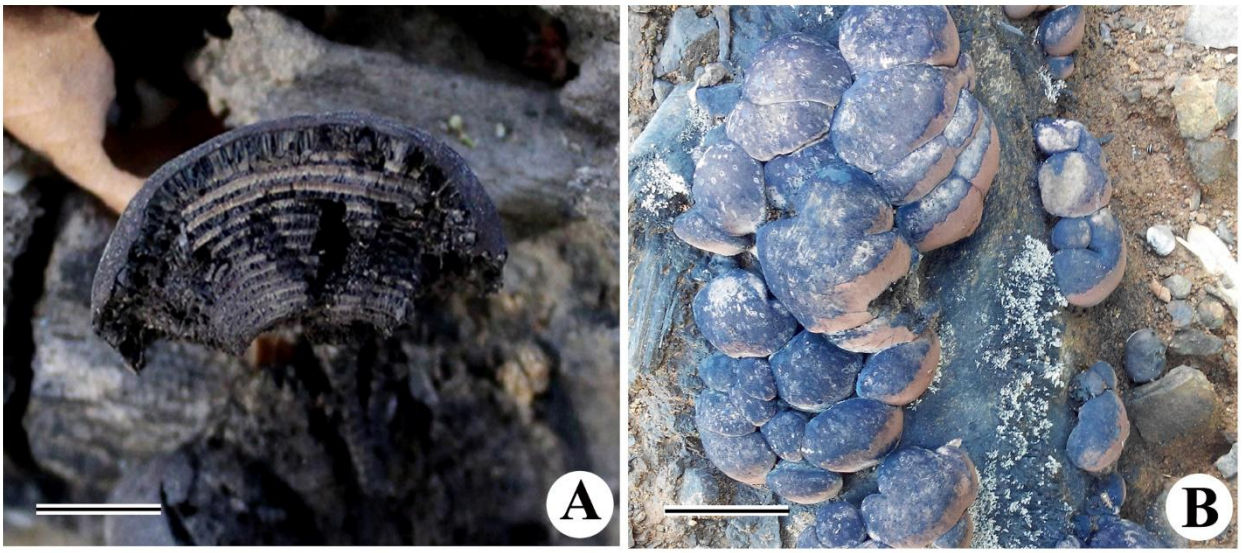

Fig. 1 – Fruiting bodies of *Daldinia*. A: *Daldinia concentrica*, B: *D. eschscholtzii*. Scale bar: A = 8 mm, B = 15 mm.

Xylaria apiculata Cooke, Grevillea 8 (46): 66 (1879). Fig. 2A

Stromata gregarious, occasionally fasciculate to solitary and scattered, slender, upright, stipate, often unbranched, long ranging from 1–6 cm in height × 1–3 mm across. Surface is dark black, with raised lines, dense and black stipe. Fertile portion of the stromata is sub-apical, cylindrical in section and rounded or apiculate at 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 brown, unicellular, ellipsoid with rounded ends and 7–12 × 20–28 µm in size.

Materials examined – Junagadh, Ratanmahal, Waghai, Sagai, host: decaying decorticated, unknown wood samples, collectors: Ms. HP Patel and Dr. KS Rajput, date: August 2014, September 2014, code#: KSR0178

Xylaria carpophila (Pers.) Fr. Summa vegetabilium Scandinaviae 2: 382 (1849). Fig. 2B

Stromata long, slender, cylindrical and branched or unbranched extended to fertile portion which is cylindrical to oval, about 6–7 cm in length, leading to the rounded or pointed distinct apex, texture is rough. Initially white when young and greyish black to black stalk at maturity. The apical tip is rusty and yellow to off white, rounded. Perithecia mammiform, 0.9–1 mm × 0.8–1.4 mm in diameter with papillate ostioles. Asci 200–280 µm × 6–6.5 µm in length and diameter respectively. Ascospores pale yellow to dull white, 8–9 × 21–24 µm in size.

Materials examined – Girnar, Waghai, Ahawa, Panchmahal, host: on humus rich soil and leaf litter, collectors: Mr. AM Vasava, Dr. RD Koyani and Dr. KS Rajput, date: July 2014, August 2014, code#: KSR0098.

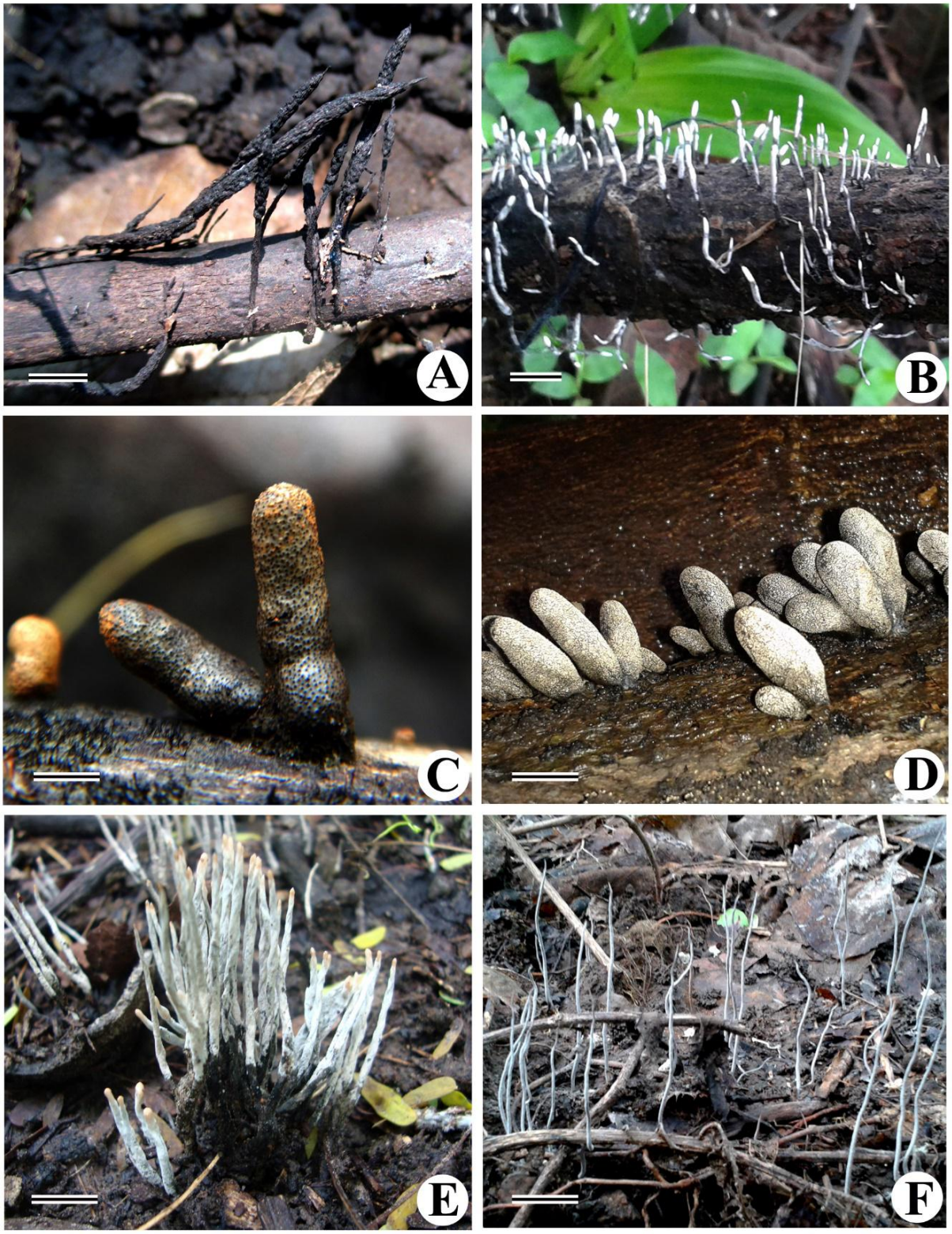

Fig. 2 – Fruiting bodies of *Xylaria* species. A: *X. apiculata*, B: *X. carpophila*, C: *X. cubensis*, D: *X. curta*, E: *X. feejeensis*, F: *X. filiformis*. Scale bar: A, C = 1 cm, B = 15 mm, D = cm, E = 2 cm, F = 3 cm.

Xylaria cubensis (Mont.) Fr, Nova Acta Regiae Societatis Scientiarum Upsaliensis 1: 126 (1851). Fig. 2C

Stromata variable, cylindrical, solitary, unbranched, tough, with rounded tip and 2–10 cm long and 1–2 cm thick, stalk very short and surface is hairless, smooth which gets dotted at maturity and become crustose and hard. Fruiting body is club shaped and bronze to brown in colour which

becomes dark with age. Entire body is fertile. Perithecia globose to elongate, 0.5–0.8 mm × 0.6–1 mm in diameter with papillate ostiole. Asci cylindrical, 150–200 µm length × 6–8 µm width, ascospores are brown to dark brown in colour, fairly small, uniseriate with overlapping ends, smooth, rounded and 3–5 × 7–9 µm in size, unequilateral with one side flat to concave and the other side round, elliptic in top view.

Materials examined – Vansda, Polo forest, Dediapada, Vadodara, Ratanmahal, host: on wood logs of *Pongamoea, Leucena leucocephala, Cassia fistula*, collectors: Ms. HR Patel, Dr. RD Koyani and Dr. KS Rajput, date: August 2014, September 2014, October 2014, code#: KSR0174

Xylaria curta Fr. Nova Acta Regiae Societatis Scientiarum Upsaliensis 1: 126 (1851). Fig 2D

Stromata often sessile, growing solitary or in clusters fertile part elongated, cylindrical with round apex, appear as dark brown and turn much darker with maturity and 5–15 cm long × 5–10 mm in diameter. External texture is black to golden brown, rough and wrinkled while internally white or cream coloured. Perithecia immersed, 0.2–0.6 mm diameter with papillate ostiole. Asci cylindrical, uni-seriate and 100–130 µm length × 5–7 µm broad. Ascospores dark brown, unicellular, smooth, uni-seriate, cylindrical, ellipsoidal-in-equilateral, and 17–18 × 30–35 µm with straight germ slit running to full length of the spore.

Materials examined – Vadodara, Waghai, Gandhinagar, host: decaying unidentified wood log, collector: Ms. HP Patel, date: August 2014, September 2014, October 2014, code#: KSR0201

Xylaria feejeensis (Berk.) Fr. Nova Acta Regiae Societatis Scientiarum Upsaliensis 1: 128 (1851). Fig. 2E

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 width. Stromata surface rough, hard and non-hairy. Stalks 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.

Materials examined – Gandhinagar, Vadodara, Dangs, Girnar, Ahawa, Dediapada, host: on soil as well as dead wood log of *Tectona grandis* and other unknown decaying wood, collectors: Ms. HR Patel and Dr. RD Koyani, date: August 2014, September 2014, October 2014, code#: KSR0169

Xylaria filiformis (Albertini & Schwein) Fr. Summa vegetabilium Scandinaviae 2: 382 (1849). Fig. 2F

Stromata simple, long, slender, solitary, scattered and branched 4–10 cm long × 2 mm width, filiform and black smooth surfaced, which become wrinkled at maturity. The stalk is long; smooth with fertile tip which very thin, distinct, slightly undulating, light brown in color. 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 other round side.

Materials examined – Girnar, Dangs, Ahawa, Ratanmahal, host: plant debris and fallen leaves or leaf litter, collectors: Dr. RD Koyani and Dr. KS Rajput, date: July 2013, August 2014, code#: KSR0019

Xylaria gigentea (Zipp. & Lév.) Fr., Nov.Symb:127 (1845). Fig. 3A

Stromata erect, subcylindric, clavate, surface rough, reaching up to 20–25 cm and 5–8 cm in diameter, hollow, cream coloured when young and turn dark black at maturity. Perithecia monostichous, 100–200 × 200–350 µm in diameter. Ascospores brown with indistinct germ slit, 4.9–9.2 × 8–14.1 µm in size.

Materials examined – Girnar forest, host: on soil, collectors: Dr. RD Koyani and Dr. KS Rajput, date: September 2013, March 2014, August 2014, code#: KSR0062

Xylaria hypoxylon (Linn. ex Hooker) Greville, Flora Edinensis: 355 (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 lengths × 7–8 µm width, ascospores black, uni-seriate, smooth, slightly bean-shaped, 4.5–6 × 11.4–12.4 µm, un-equilateral with one side and rounded other side.

Materials examined – Vadodara, Chotaudepur, Girnar, Dangs, Polo forest, host: decaying wood log/sticks, dry fruits shells of *Feronia limonia*, *Cassia fistula*, collectors: Dr. RD Koyani and Dr. KS Rajput, date: July 2013, September 2014, code#: KSR0021

Xylaria longipes Nitschke & Pyrenomyces, Germanici 1: 14 (1867). Fig. 3B

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

Materials examined – Polo forest, Jambughoda, Girnar, Vadodara, host: decaying wood log/sticks, collectors: Dr. RD Koyani and Dr. KS Rajput, date: July 2014, August 2014, September 2014, code#: KSR0099

Xylaria nigripes (Klotzsch) Cooke, Grevillea 11 (59): 89 (1883). Fig. 3C

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

Materials examined – Ratanmahal, Sagai, Dediapada, Dangs, Vadodara, host: on soil, collectors: Dr. RD Koyani and Dr. KS Rajput, date: August 2013, August 2014, September 2014, code#: KSR0059

Xylaria primorskensis Y.M. Ju, H.M. Hsieh, Lar. N. Vassiljeva & Akulov, Mycologia 101 (4): 549 (2009)

Stromata are cylindrical-clavate, unbranched and extended to the fertile rounded apex. Stipes stout, long reaching up to 12 cm in length and 6–12 mm in diameter, surface wrinkled, externally the fertile portion of the stipe is blackish with specific brown ring on the fertile apex while white internally. Perithecia are spherical, 0.4–0.6 mm in diameter with papillate ostioles. Asci with eight ascospores arranged in uniseriate manner, cylindrical and 130–180 µm in length × 7–9 µm in width. Ascospores are unicellular, ellipsoid-inequilateral and smooth surfaced with narrowly rounded ends and 9–11 × 4–5 µm, with a straight germ slit at complete spore length.

Materials examined – Sarkhadiya Hanuman, Junagadh, Jessore, Ratan Mahal, host: dead wood log and thick braches of fallen trees, collectors: Dr. RD Koyani and Dr. KS Rajput, date: August 2013, July 2014, August 2014, code#: KSR0048

Xylaria polymorpha (Pers. ex Fr.) Grev, Flora Edinensis: 355 (1824). Fig. 3D, E

Fruiting body commonly grows on the decaying wood near the base. Stromata 3–20 cm long and 2–5 cm across, occurs alone or in cluster, 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 the age. Perithecia black, sub-spherical, and 0.2–1 mm in diameter. Asci cylindrical, stipitate, long and 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 third of the spore's length, 5–10 × 20–30 µm in size.

Materials examined – Sarkhadiya Hanuman, Junagadh, Jessore, Ratan Mahal, host: trunk base of decaying trees of *Bombax*, *Lannea*, *Butea* and unknown wood logs, collectors: Dr. RD Koyani and Dr. KS Rajput, date: September 2013, March 2014, August 2014, code#: KSR0064

Xylaria psidii J.D. Rogers & Hemmes, Mycologia 84: 167 (1992).

Stromata are upright, 5–6 cm long, branched or unbranched, single or in clusters and extended to the fertile cylindrical or conical apex. Perithecia are embedded, stipes about 1.5 mm thick, twisted, externally brown and internally white coloured while fertile part black. Texture hard, asci eight spored arranged in uni-biseriate manner. Ascospores are black-brown, unicellular, ellipsoid inequilateral, smooth with acute ends and 4–5 × 7.3–11 µm in size with straight germ slit spore-length.

Materials examined – Girnar forest, Dediapada, Panchmahal, Dangs, host: unknown decaying wood log, collectors: Dr. RD Koyani and Dr. KS Rajput, date: August 2013, July 2014, August 2014, September 2014, code#: KSR0031

Xylaria regalis Cooke, Grevillea 11 (59): 86 (1883).

Stromata cylindrical in early stages of growth and later become flattened; upper branches powdery white when young and become black at maturity while the stalk remains black. External surface wrinkled, with conspicuous perithecial mounds. Ascospores are unicellular, ellipsoid inequilateral and smooth 12–15 × 4–6µ in size.

Materials examined – Junagadh, Dang, Pavagadh, Dediapada, Vadodara, host: unidentified dead wood log, collectors: Dr. RD Koyani and Dr. KS Rajput, date: August 2013, July 2014, August 2014, September 2014, code#: KSR0045

Discussion

Angiosperm diversity of Gujarat state has been well document but similar studies on fungal diversity are lacking. Gujarat is known for its wide range of climatic variations starting from moist deciduous forest (part of Western Ghat, i.e. South Gujarat) to pure desert such as Great Rann of Kutchh. Few studies on fungal diversity of Gujarat have been carried out earlier (Arya 2004; Arya et al. 2008; Nagdesi & Arya 2012, 2013, 2014a, b; Rajput et al. 2015). *Xylaria carpophila* was reported by Dennis (1956) from tropical America and from Argentina

Daldinia concentrica and *Daldinia eschscholtzii* have been described by Korat et al. (2013) and Rajput et al. (2015), whereas *Daldinia childiae* has been described for the first time in the present study. Genus *Hypoxylon* with four species mentioned here; *H. begae* and *H. fragiforme* have already been documented in our previous study (Rajput et al. 2015) while existence of *H. rickii* in Gujarat is being reported for the first time. Conclusively, current study is preliminary but very essential contribution to fungal diversity of Gujarat state and further studies are recommended to document the fungal diversity of the state. State of Gujarat is never explored for the fungal diversity. Available literature indicates that most of the studies on fungal diversity of Gujarat state are either from plant or human pathogen while forest areas are 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.

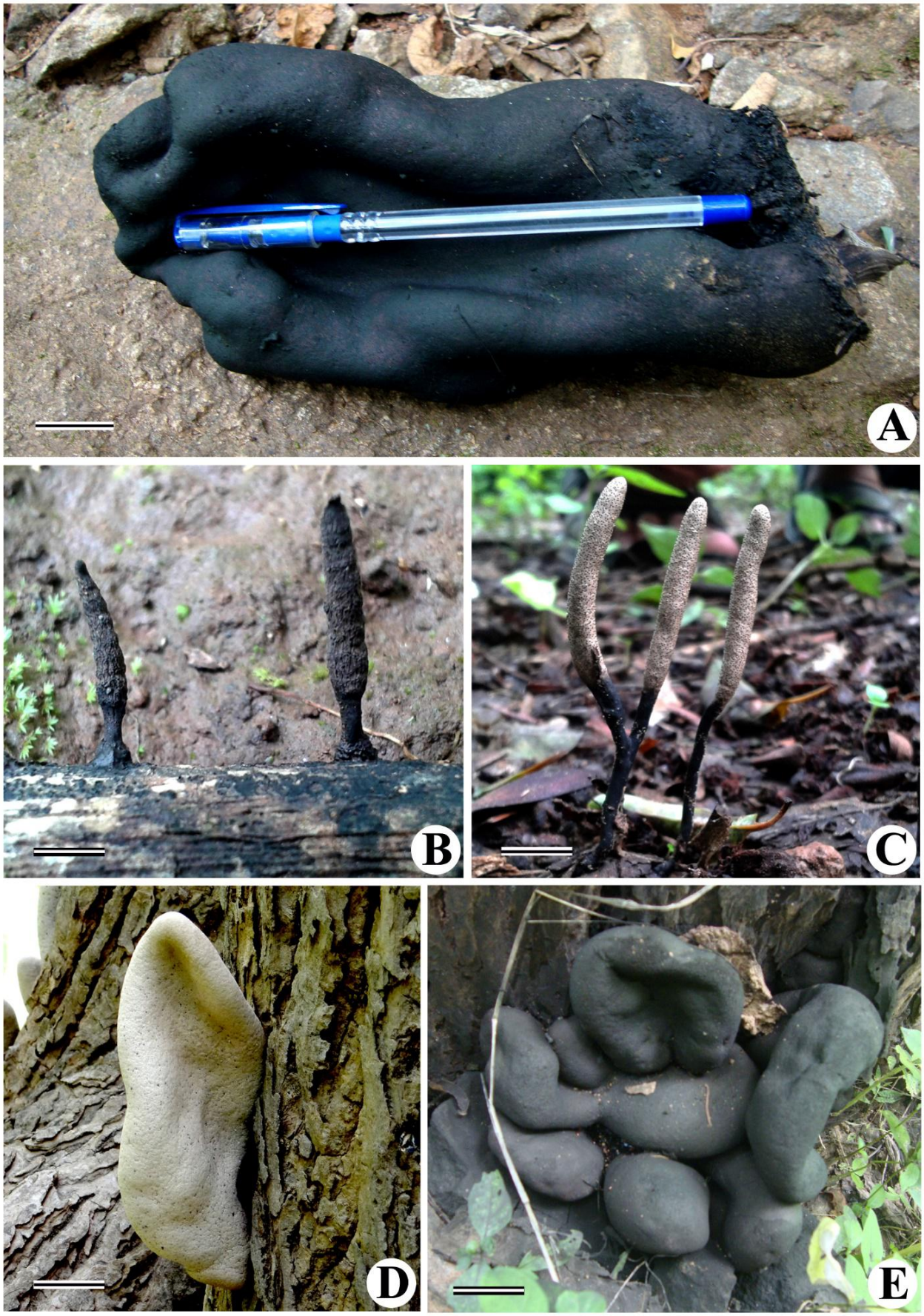

Fig. 3 – Macroscopic features of *Xylaria*. A: *X. gigentea*, B: X. *longipes*, C: *X. nigripes*, D, E: *X. polymorpha*. Scale bar: A, B = 2 cm, C = 15 mm, D, E = 25 mm

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