Species

On the *Xylaria* in scrub jungles of southwest India

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ABSTRACT

Xylaria is a widely distributed genus belong to the family Xylariaceae and grows on a wide variety of substrates in different habitats. Up to 60 species of *Xylaria* have been reported from the Indian subcontinent, while southwest India is known for about 30 species. Recently, four species of *Xylaria* (*X. arbuscula, X. grammica, X. minuta* and *X. oxyacanthae*) were found to grow on various habitats and substrates during an inventory of scrub jungles of southwest India during 2019-21. *Xylaria arbuscula* and *X. grammica* were confined to dead bark, while *X. minuta* and *X. oxyacanthae* were grown on the dead twigs and humus, respectively. This study reports description (of the above species), distribution, habitat specificity and substrate specificity of *Xylaria* spp. in southwest India based on the literature.

Keywords: Macrofungi, substrates, habitat specificity, substrate specificity, conservation

1. INTRODUCTION

Xylaria (Xylariaceae) is a cosmopolitan genus capable to grow on a wide range of substrates (Roger, 1979). It has carbonaceous, simple or branched, cylindrical or clavate, globoid or irregular and stipitate or sessile fruit bodies (Trierveiler-Pereira et al., 2009). The diameter of stroma differs widely from 0.5 mm to 55 mm (*X. filiformis* and *X. acuminatilongissima*, respectively) (Rogers and Samuels, 1986; Latha et al., 2015). They are capable to lead saprophytic (e.g., soil, bark, wood, leaf litter, dead pods, seeds and termite nests) as well as endophytic (e.g., orchids, palms and trees), parasitic and symbiotic (e.g., insect nests) lifestyles (Mohanan, 2011; Patil et al., 2012; Rajulu et al., 2013; Thirumalesh et al., 2014; Karun and Sridhar, 2015; Latha et al., 2015; Daranagama et al., 2016). From the Indian subcontinent, about 60 species of *Xylaria* are reported, while southwest India possesses nearly 30 species on various substrates and ecosystems (Karun and Sridhar, 2015; Patel and Krishnappa, 2017). This study highlights the occurrence of four species of *Xylaria* in scrub jungles of southwestern India with a brief account of habitat and substrate specificity of *Xylaria* in southwest India based on literature.

2. METHODOLOGY

Study region

The chosen location for the survey *Xylaria* situated at a distance of ~5-8 km from the coast of the Arabian Sea (Dakshina Kannada, Karnataka) (12º48'58.2' N, 74º55' E) (104-112 m asl) (Figure 1). About 150 ha of this undulating terrain about five decades largely consists of grassland with patches of scrub jungles. In the 1970s, of cashew (*Anacardium occidentale*) was encouraged along with natural vegetation. Mixed plantations (*Acacia*, *Anacardium*, *Azadirachta*, *Casuarina*, *Cocos* and *Pongamia*) were established by the forest department. Subsequently, students of the National Service Scheme (NSS) are instrumental to seed the native vegetation in this region. Some of the common genera of native tree species in this region include *Borassus*, *Careya*, *Caryota*, *Holigarna*, *Hopea*, *Macaranga*, *Sapium*, *Syzygium*, *Tamarindus* and *Terminalia*.

Figure 1 View of typical scrub jungles of southwest India possessing *Xylaria* species.

3. DESCRIPTION

Sporocarp characteristics were recorded on the sampling site, they were brought to the laboratory within 1-2 hours. The examination was carried out to follow the diagnostic features using by the magnifying lens as well as a compound microscope (Nikon YS100, Nikon Corporation, Tokyo, Japan). The diagnostic keys were followed for identification on a morphological basis (Rogers and Samules, 1986; Lee et al., 2002; Ju and Hsieh, 2007; Rogers et al., 2008; Kshirsagar et al., 2009; Trierveiler-Pereira et al., 2009). On oven-drying (55-60ºC) they were preserved in a blend of water-ethanol-formaldehyde (14:5:1).

Each specimen was studied for its general features, stromata, substrate and distribution. Sporocarps were removed from the substrate using a sharp knife and debris was removed using a soft brush. Sectioning was made using a sterile blade, followed by staining with cotton blue in lactophenol. The microscopic observations such as the size, colour of perithecial ascospores were observed using a compound microscope. Immature and mature stromata were studied microscopically to follow the nature of perithecia, asci and ascospores and dimensions.

***Xylaria arbuscula* Sacc. Michelia 1: 249. 1878**

Occurs in small troops, annual, rare, odour and taste are not distinct and inedible. Initially stromata attain long, smooth, whip-like, dull-black with smoky-white spore deposits. It becomes elongated, black, cylindric to fusoid, warty, fertile head, tapering at the tip, blackish short or long sterile stem embedded in wood with small rooting base, cylindric-fusoid fertile stromata and white hard flesh on maturity. Papillate ostiole and stromata measures 10-50 mm × 1-2 mm. Black perithecia, sub-spherical, embedded in the fertile head, arranged as monolayer below the surface and measures 0.5-0.6 mm diameter. Asci cylindrical, stipitate, long, 8-spored and measure 50-70 × 5-6 µm. Ascospores brown, uniseriate, ellipsoidal, aseptate and measure 10-15 × 5-6 µm.

Substrate and distribution

Grown on the dead bark of *Pongamia pinnata* in Assaigoli village near Konaje, Mangalore, Karnataka, India (June-September) (Sridhar, 2020) (Figure 2).

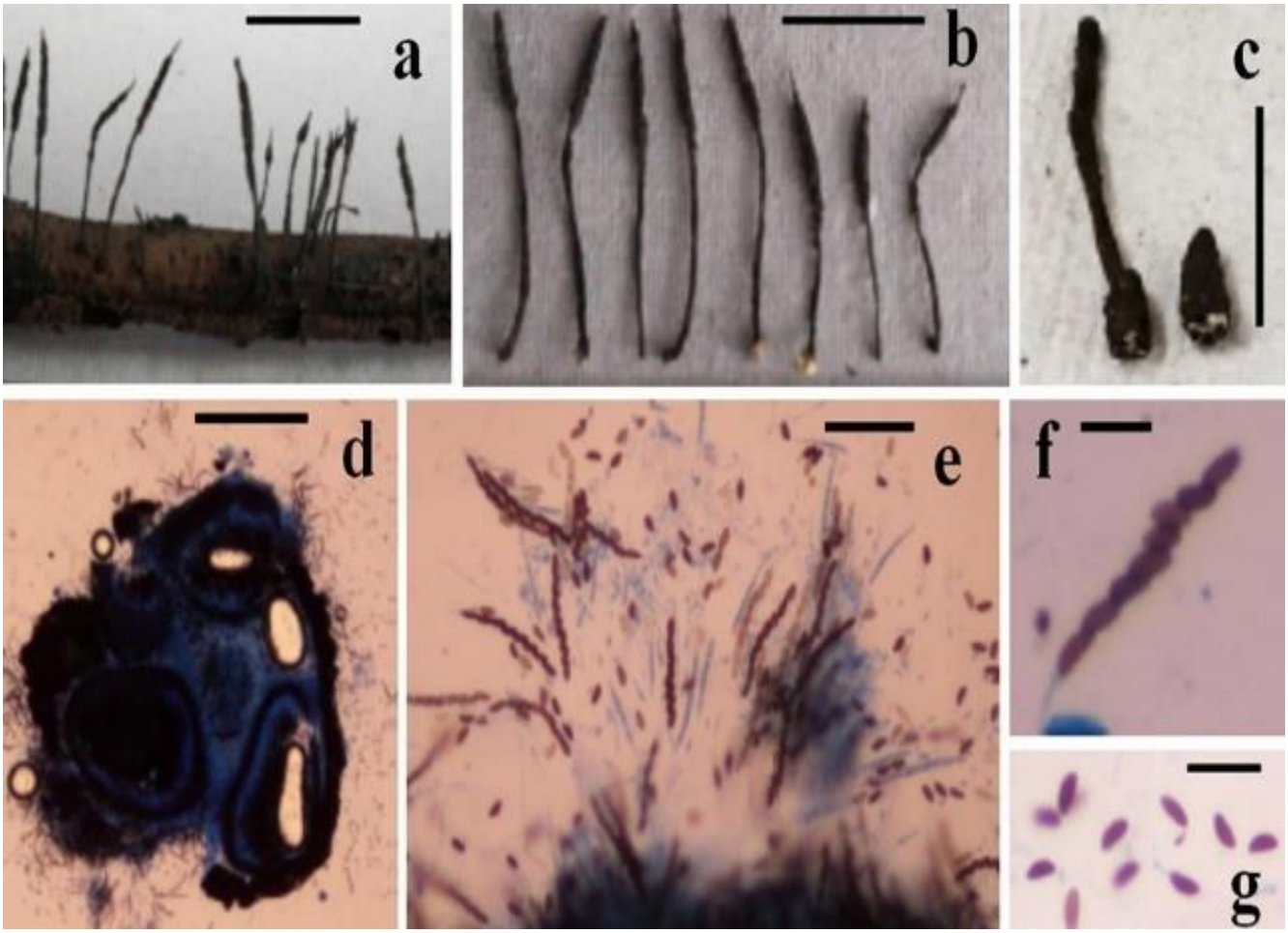

Figure 2 *Xylaria arbuscula* grew on a dead twig of *Pongamia pinnata* (a); nature of mature stromata (b); cross-section of stromata (c); microscopic view of cross-section of mature stromata (d); spread of asci and ascospores (e); ascus (f); ascospores (g) (Scale bar: a and b, 10 mm; c, 5 mm; d, 200 µm; e, 50 µm; f, 20 µm; g, 10 µm).

***Xylaria grammica* (Mont.) Fr., Nov. Act. Reg. Soc. Sci. Upsal. (Ser. 3) 1: 128 (1851)**

Occurs in small troops, rare, annual, odour and taste not distinct and inedible. Stromata initially dull-black, long and smooth with smoky-white spore deposits. It becomes brown, cylindric to fusoid, elongated, smooth to warty, longitudinal striations, round to obtuse apex, fertile head into blackish-brown to dull-brown, short stem deeply embedded in the bark with short rooting base, occasionally branched at the tip and white hard flesh on maturity. Papillate ostiole and stromata measures 20-50 mm × 2-4 mm. Sub-spherical perithecia, black, embedded in the fertile head, arranged as a dense layer below the surface and measure 0.1-0.2 mm diameter. Asci long stipitate, cylindrical, 8-spored and measure 40-60 × 3.5-4.5 µm. Ellipsoidal ascospores, uniseriate, brown, aseptate and measure 4-5 × 2-3 µm.

Substrate and distribution

On the dead attached bark of *Eucalyptus tereticornis* in Konaje, Mangalore, Karnataka, India (July-September) (Sharathchandra, 2020) (Figure 3).

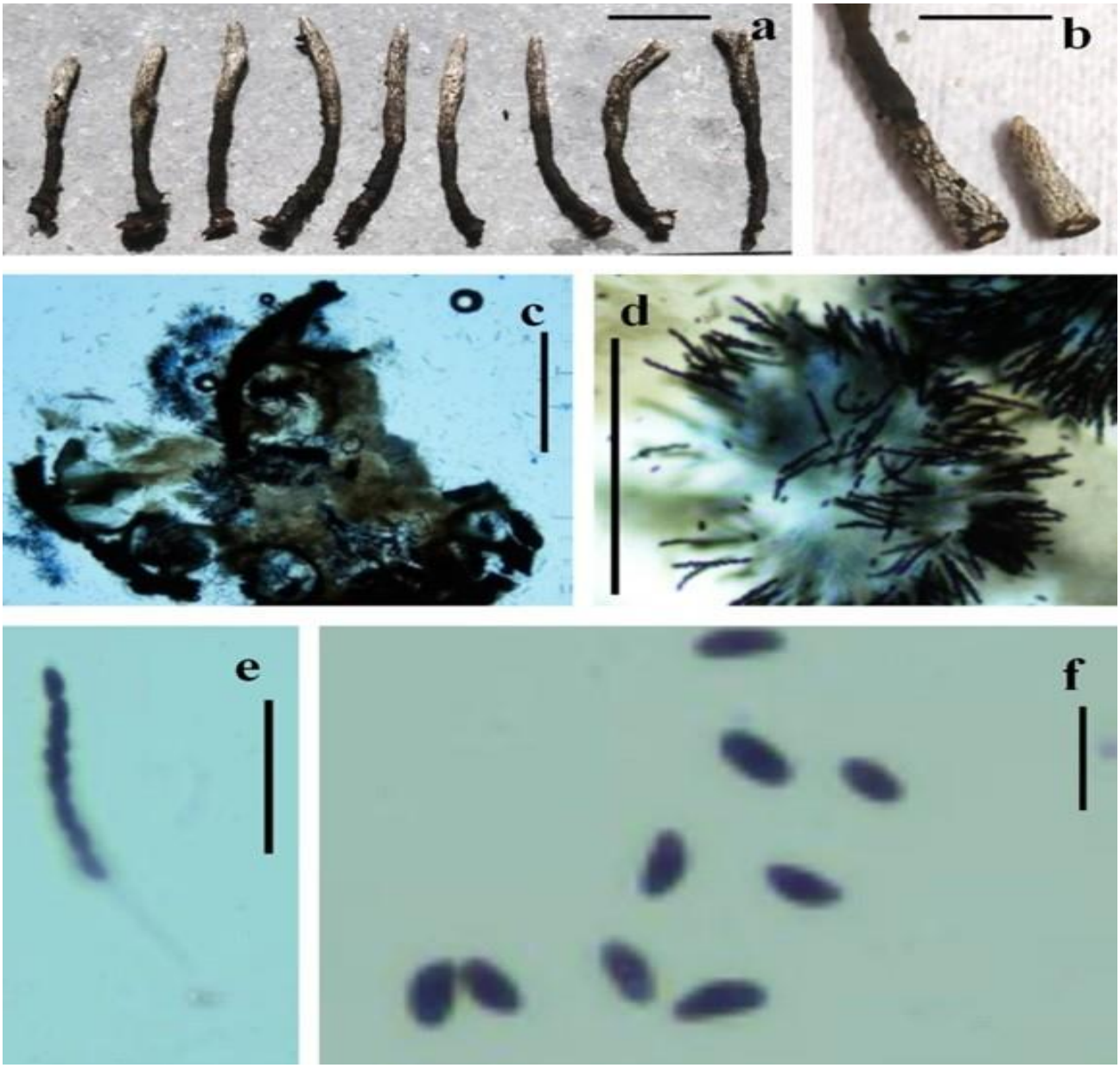

Figure 3 *Xylaria grammica* fruit bodies separated from dead bark of *Eucalyptus tereticornis* (a); cross-section of stromata (b); microscopic view of mature stromata (c); spread of asci and ascospores (d); ascus (e); ascospores (f) (Scale bar: a and b, 10 mm; c and d, 5 mm; e, 50 µm; f, 20 µm).

***Xylaria minuta* Panwar, *Indian Phytopath.* 27(1): 110 (1974)**

Occurs solitarily, annual, frequent, taste and odour not distinctive and inedible. Erect stromata, slightly bent, measure 5-25 × 2 mm wide at the broadest part, black, rough with long hairs and protruded sub-apical with a spiny tip. The apex spiny, fertile part is bulged below the spine. Perithecia sub-spherical, black, embedded in fertile head and measures 0.4-0.8 mm diameter. Asci long, uniseriate, cylindrical, stipitate, 8-spored, black and measure 50-90 × 6-8 µm. Ellipsoid-inequilateral ascospores, dark-brown, aseptate and measure 8-12 × 4.5-6 µm.

Substrate and distribution

On decaying unidentified fallen twigs in scrub jungles of Konaje, Mangalore, Karnataka, India (July-September) (Sridhar, 2019) (Figure 4).

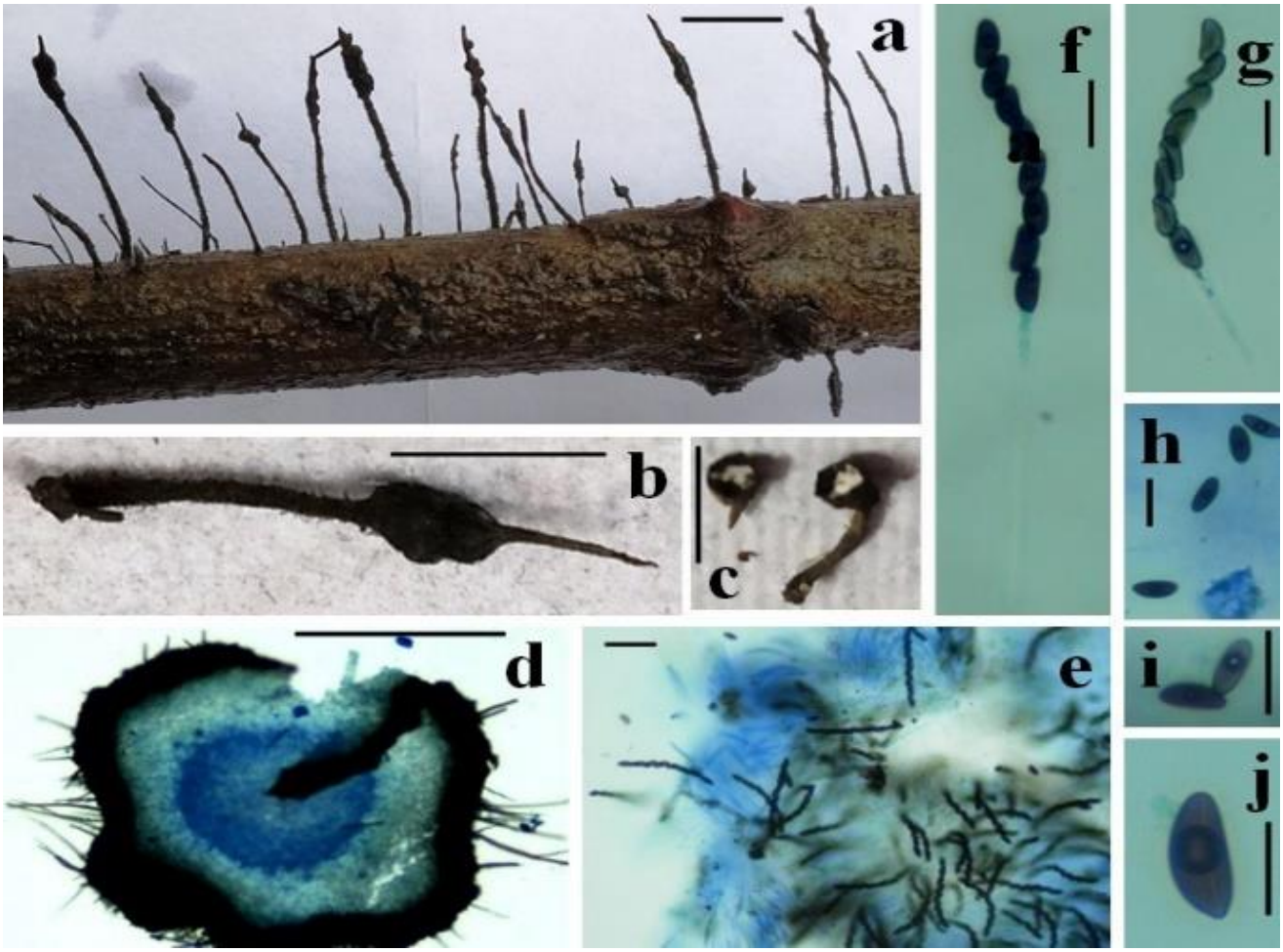

Figure 4 Immature and *Xylaria minuta* grew on a twig (a), nature of stromata (b), transverse section of mature stromata (c), microscopic view of a transverse section of immature stromata (d), microscopic view of a transverse section of mature stromata (e), asci (f, g), ascospores (h-j) **(**Scale bar: a, 10 mm; b and c, 5 mm; d, 10 mm; e, 50 μm; f-i, 20 μm; j, 10 μm).

***Xylaria oxyacanthae* Tul. & C. Tul., *Saccardo's Syll. fung*. II: xvii; IX: 541 (1863)**

Usually occurs in clusters on soil or humus, annual, rare, odour and taste not distinctive and inedible. Stromata develop on composted soil, light-gray, smooth, pointed to blunt tips, small or long rooting base, usually branched, rooting base black, cylindric, flesh white hard and brittle. Papillate ostiole and stromata measures 50-80 mm × 3-5 mm. Sub-spherical perithecia, black, embedded in the fertile head, measure 0.2-0.4 mm diameter and arranged below the surface as a dense monolayer. Asci long, cylindrical, stipitate, 8- spored and measures 30-50 × 3-4 μm. Ellipsoid-inequilateral ascospores, uniseriate, brown, aseptate and measure 5-6 × 3-4 μm.

Substrate and distribution

Embedded in humus in coconut tree basins (Cocos nucifera) in scrub jungles of Konaje, Mangalore, Karnataka, India (July-September) (Sridhar, 2019) (Figure 5).

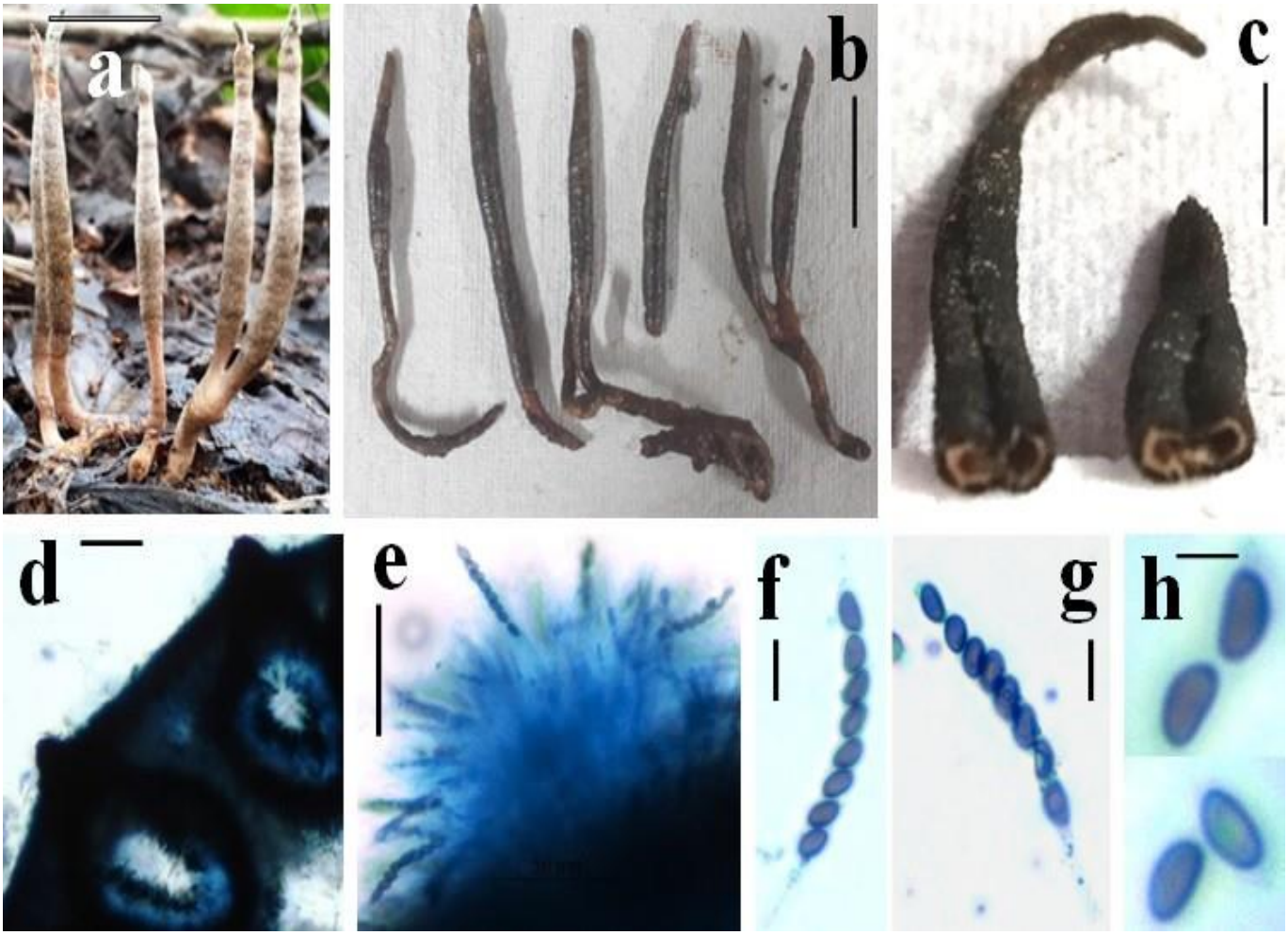

Figure 5 Mature stromata of *Xylaria oxyacanthae* (a), nature of stromata (b), transverse section of mature stromata (c), microscopic view of a transverse section of mature stromata (d, e), asci (f, g) and ascospores (h) (Scale bar: a and b, 5 mm; c, 2 mm; d, 100 µm; e, 50 µm; f and g, 10 µm; h, 5 µm).

4. DISCUSSION

A literature survey revealed the occurrence of about 30 species of *Xylaria* in southwest India (Karun and Sridhar, 2015; Patil and Krishnappa, 2017; Himani and Krishnappa, 2020). Based on the literature in the southwest of India, *Xylaria* spp. were found in eight habitats (Figure 6). Forest ecosystems possess as many as 46 species of *Xylaria* followed by scrub jungles (9 spp.) and agroforests (4 spp.), while it was least in arboretum and garden (1 species each). Among the eight habitats, 21 species of *Xylaria* were confined in one of the habitats. Three species each were confined to two and three habitats. Two species were confined to four habitats and one species was confined to five habitats.

In addition to substrates preferred by four species of Xylaria in our study, X. arbuscula was found on wood, twigs and endophytic; X. grammica preferred wood/branches; X. minuta found on wood; X. oxyacanthe grown on buried fruits (Table 1). Based on the substrate in southwest India, Xylaria spp. preferred up to 10 substrates (Figure 6). Among 10 substrates, wood supported as high as 24 species of Xylaria followed by twigs, leaf litter, soil and termite mound (5 spp. each). Among the 10 substrates, 13 species of Xylaria were confined to one of the substrates, while eight and one species were confined to two and seven substrates, respectively. However, many earlier reports were devoid of specific substrates on which Xylaria spp. were colonized.

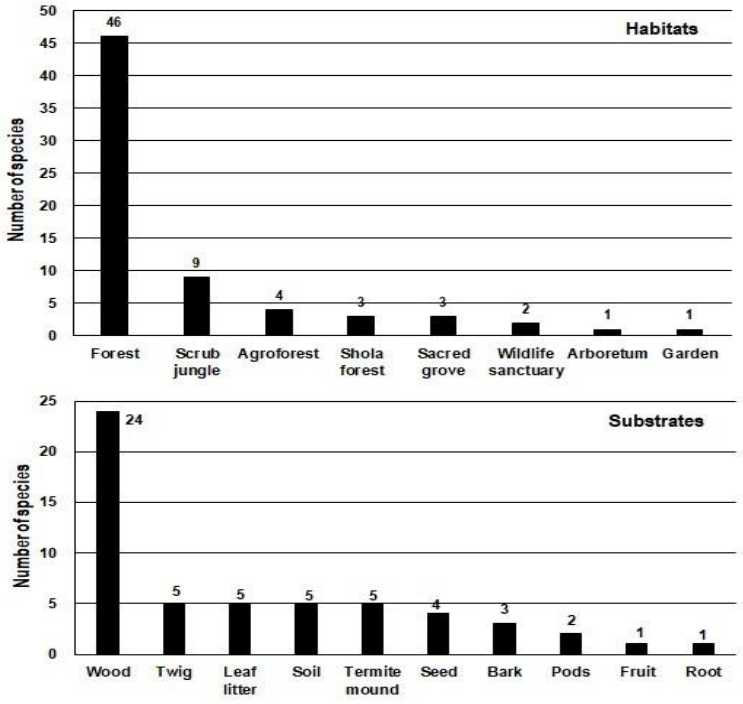

Figure 6 Occurrence of *Xylaria* spp. in different habitats and substrates in southwest India.

Table 1 Reports on four species of *Xylaria* in India (- not defined).

	Substrate	Locality	Reference
Xylaria arbuscula Sascc.	Wood	Vatemakki, Kargal forest, Karnataka	Nejakar et al., (2012)
	Hardwood twigs	Rosoma forest, Nagaland	Chuzho & Dkhar, (2019)
	Wood	Tufanganj-I, West Bengal	Das et al., (2020)
	Endophytic (*Blumea axillaris*)	Valparai Hills, Coimbatore, Tamil Nadu	Lavanya et al. (2021)
	Bark (*Pongamia pinnata*)	Konaje, Karnataka	This study
Xylaria grammica (Mont.) Mont.	-	Mulashi forest, Maharashtra	Kshirsagar et al., (2009)
	Wood	Jambekoppa, Keladi & Joga, Karnataka	Patel & Krishnappa, (2017)
	Wood/branches	Hmuifang forest, Mizoram	Vabeikhokhei et al., (2019)
	Bark (*Eucalyptus tereticornis*)	Konaje, Karnataka	This study
Xylaria minuta Panwar	Wood	Keladi, Karnataka	Patel & Krishnappa, (2017)
	Twigs	Konaje, Karnataka	Dattaraj et al., (2020)
	Twigs	Konaje, Karnataka	This study
Xylaria oxyacanthe Tul. & C. Tul.	Buried fruits (*Diospyrous melanoxylon*)	Bhadra Wildlife Sanctuary, Karnataka	Himani & Krishnappa, (2020)
	Humus (in *Cocos nucifera* basin)	Konaje, Karnataka	This study

Among the four species of *Xylaria* studied, except for *X. oxyacanthae* rest have been assessed for the biochemical components responsible for antioxidant activity (Syed et al., 2023). Total phenolics > flavonoids > tannins > vitamin C in *X. arbuscula, X. grammica* and *X. minuta*. The reducing power, total antioxidant activity, ferrous ion-chelation capacity and radical-scavenging activity of these *Xylaria* were higher in methanol than in chloroform extract.

5. CONCLUSION

The lateritic scrub jungles inventoried developed over five decades with a wide range of flora and fauna. In addition, they support a variety of macrofungi involved in the decomposition of lignocellulosic organic matter. The scrub jungles in southwest India owing to characteristic climatic conditions (coastal weather), geography (lateritic base) and biota (flora, fauna and microbes) became a hub of several macrofungi especially *Xylaria*, which involve in organic matter recycling as well as biogeochemical cycles. Besides, the presence of many bioactive components and antioxidant potential, *Xylaria* are employed in ethnic medicine to treat many diseases such as insomnia, trauma and stomach disorders. In view of the significance of macrofungi including *Xylaria*, there is a need to conserve the forests and their woody litter from human interference to maximize their ecosystem processes and services.

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Authors' contributions

All authors contributed equally.

Ethical approval

Xylaria from scrub jungles of southwest India was observed and recorded in the study. The ethical guidelines are followed in the study for species observation & identification.

Informed consent

Not applicable.

Conflicts of interests

The authors declare that there are no conflicts of interests.

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Data and materials availability

All data associated with this study are present in the paper.

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