

APPENDIX 21 - Note on Common Wood Decay Fungi on Urban Trees of Hong Kong

Note on Common Wood Decay Fungi on Urban Trees of Hong Kong

**Greening, Landscape and Tree Management Section
Development Bureau
The Government of the Hong Kong Special Administrative Region**

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1. INTRODUCTION

Wood decay is predominantly driven by wood decay fungi that possess a whole array of enzymes for impairing the structural strength and physiological function of living trees. In this regard, the Tree Management Office (TMO) has produced and compiled this note (with photographic illustrations) on 12 common wood decay fungi that occur on the urban trees of Hong Kong. Detailed information about the individual fungal species is based on a previous consultancy study commissioned by the TMO on the “Occurrence and Distribution of Common Wood Decay Fungi on Trees of Hong Kong” undertaken by the University of Hong Kong from late 2011 to early 2014. The study involved a territory-wide baseline survey in some of the populated areas of Hong Kong and collected information on the distribution and occurrences of local wood decay (saprotrophic and pathogenic) fungi. This study is also aimed to enhance our understanding of the arboricultural significance of certain fungal decay on urban trees.

Any further enquiries on this note or related issues should be directed to:

Tree Management Office
Development Bureau
16/F, West Wing, Central Government Offices
2 Tim Mei Avenue, Tamar
Hong Kong
Email : gltns@devb.gov.hk
Tel : 2848 2334

2. PURPOSE OF THIS NOTE

This note aims to provide the government departments and other arboricultural practitioners a quick and illustrative reference for the identification of common wood decay fungi associated with living trees to facilitate early identification of problems during the Tree Risk Assessment* process and/or other routine tree inspection.

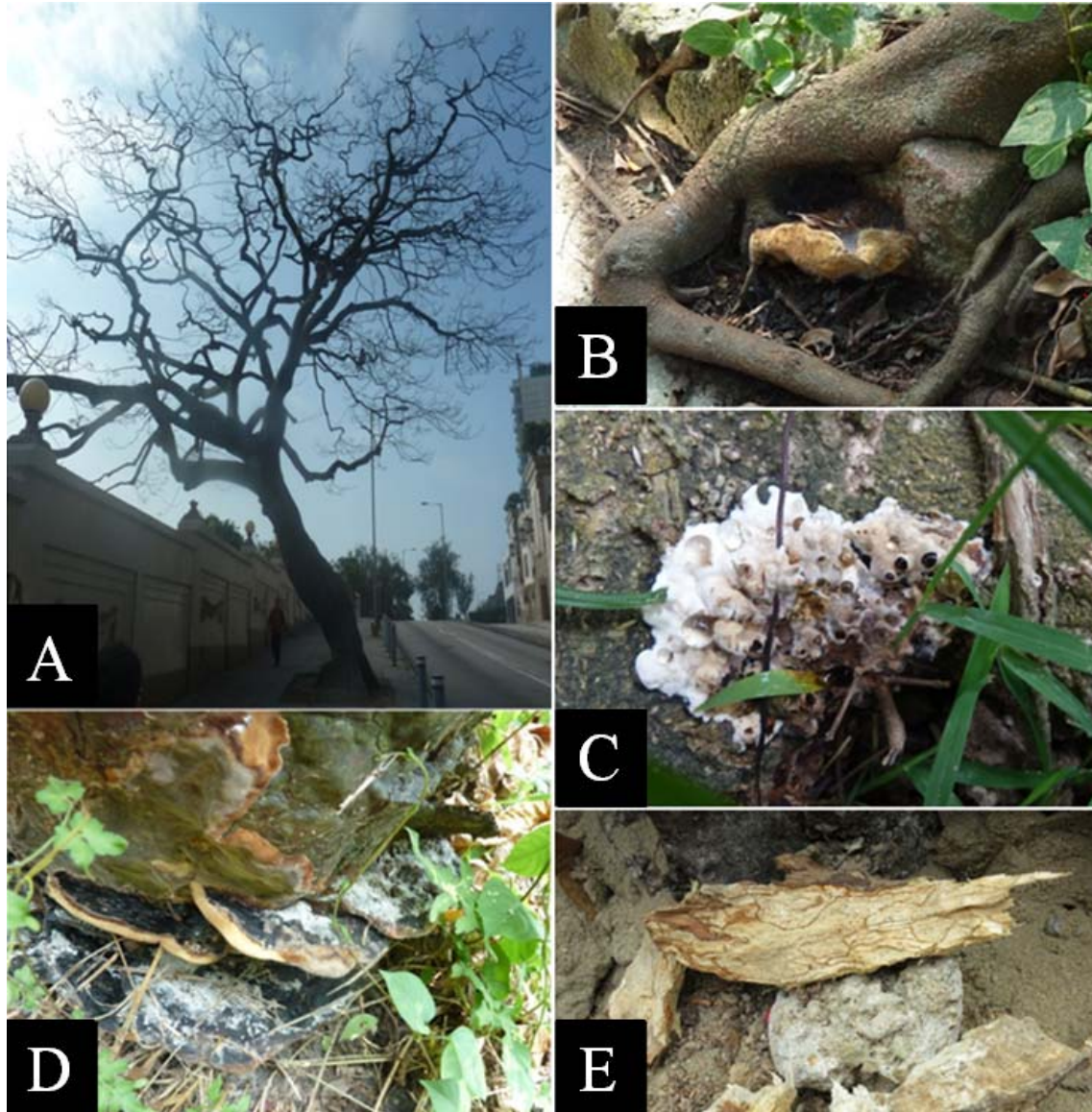
To facilitate users' application of this note, the 12 wood decay fungi have been categorised in terms of their arboricultural significance particularly the potential risks of tree failure that they may cause. Four risk categories, each of which has been assigned a specific colour code (**RED**, **ORANGE**, **YELLOW** or **GREEN** in descending order of risk) have been established taking into account the information about their pathogenicity, virulence, local occurrence, impact arising from their infection on the prognosis of the health and stability of the infected trees. Recommendations on the management of trees infected with each species are also provided. As a general rule, trees infected with wood decay fungi in the **RED** category should be urgently attended to while those in the **GREEN** category could be kept under monitoring in view of their limited impact to the trees but their presence indicate the presence of dead/decaying wood.

Nevertheless, it should be borne in mind that the presence of particular wood decay fungi is only one of the many factors that have to be considered when evaluating the potential risk of tree failure in the urban settings. Other factors that may affect the health/structural conditions of the trees under inspection should also be taken into account when formulating mitigation measures.

* Please refer to the 'Guidelines for Tree Risk Assessment and Management Arrangement on an Area Basis and on a Tree Basis' issued by the Greening, Landscape and Tree Management Section, Development Bureau, available at www.trees.gov.hk.

3. COMMON WOOD DECAY FUNGI

*Phellinus noxius*¹



(A) *Delonix regia* infected by *Phellinus noxius* resulting in abnormal defoliation. (B) Mature fruiting body of *P. noxius* on the root of a *Ficus microcarpa*. (C) Primordial stage fruiting bodies of *P. noxius* on *Celtis sinensis* (with white margin and droplets of exudates). (D) Mature fruiting bodies of *P. noxius* on a dead tree stump. (E) Mycelial nets on dead stump of *Aleurites moluccana*.

¹ *Phellinus noxius* (Corner) G. Cunn., Bulletin of the New Zealand Department of Industrial Research 164: 221 (1965).

FRUITING BODY

Mature fruiting bodies perennial, usually from about 3×4 cm to 10×20 cm up to 40×75 cm, mostly solitary, sessile; pilei applanate, dimidiate or appressed-reflexed, surface dark brown to almost black, glabrous, and narrowly but irregularly zonate, margin white then concolourous, obtuse; pore surface grayish brown to brown, irregular, polygonal, tubes in one to four layers, 1-3 mm long, similar in colour to the pore surface, tubes contrasted sharply with the deep chocolate brown of the context; spores $3\text{-}3.5 \mu\text{m} \times 3.5\text{-}4.5 \mu\text{m}$, broadly ellipsoid, smooth, thick-walled, hyaline.

DISTRIBUTION AND HOST RANGE

This fungus is prevalent in tropical and subtropical regions in different parts of the world and has been found in Asian countries and areas such as Japan, China, Hong Kong Special Administrative Region (SAR), Macau SAR, Taiwan, Malaysia, Singapore as well as Central America, Africa and Oceania.

Over 200 plant species in 59 families are known hosts to *P. noxius* worldwide. Locally, host trees species include *Acacia confusa*, *Aleurities moluccana*, *Bauhinia* spp., *Bombax ceiba*, *Celtis sinensis*, *Delonix regia*, *Ficus microcarpa*, *Ficus benjamina*, *Ficus elastica*, *Gleditsia fera*, and *Melia azedarach* etc. that grow on artificially created or disturbed sites along roadsides, on artificial slopes and in parks.

SIGNS AND SYMPTOMS

This fungus causes the Brown Root Rot (BRR) disease on trees. Infected trees would become structurally unstable and symptoms of the disease may emerge progressively through gradual thinning out of the crown, yellowing of the leaves, reduction in leaf size or shedding of leaves as a result of impaired water transportation function of the vascular system. Infected trees could die in a few months' time but may survive another one to two years. Some infected trees would suffer quick decline in conditions and wilt rapidly. Their leaves would turn brown in colour and the trees could die within weeks, with wilted leaves of the dead trees remaining attached on the branches for months. The typical signs of BRR disease include fruiting bodies (i.e. primordial/mature stages), mycelial encrustation, soil aggregates and mycelial nets.

PATHOLOGY

P. noxius is a pathogenic fungus with strong virulence causing a white simultaneous rot usually on the roots and root collars of infected trees but could occasionally be observed on locations higher up on trees. Wounds are not prerequisite for infection for this fungus as it can actively infect living trees. Infection could be by means of root to root contact and by dissemination of basidiospores from mature fruiting bodies.

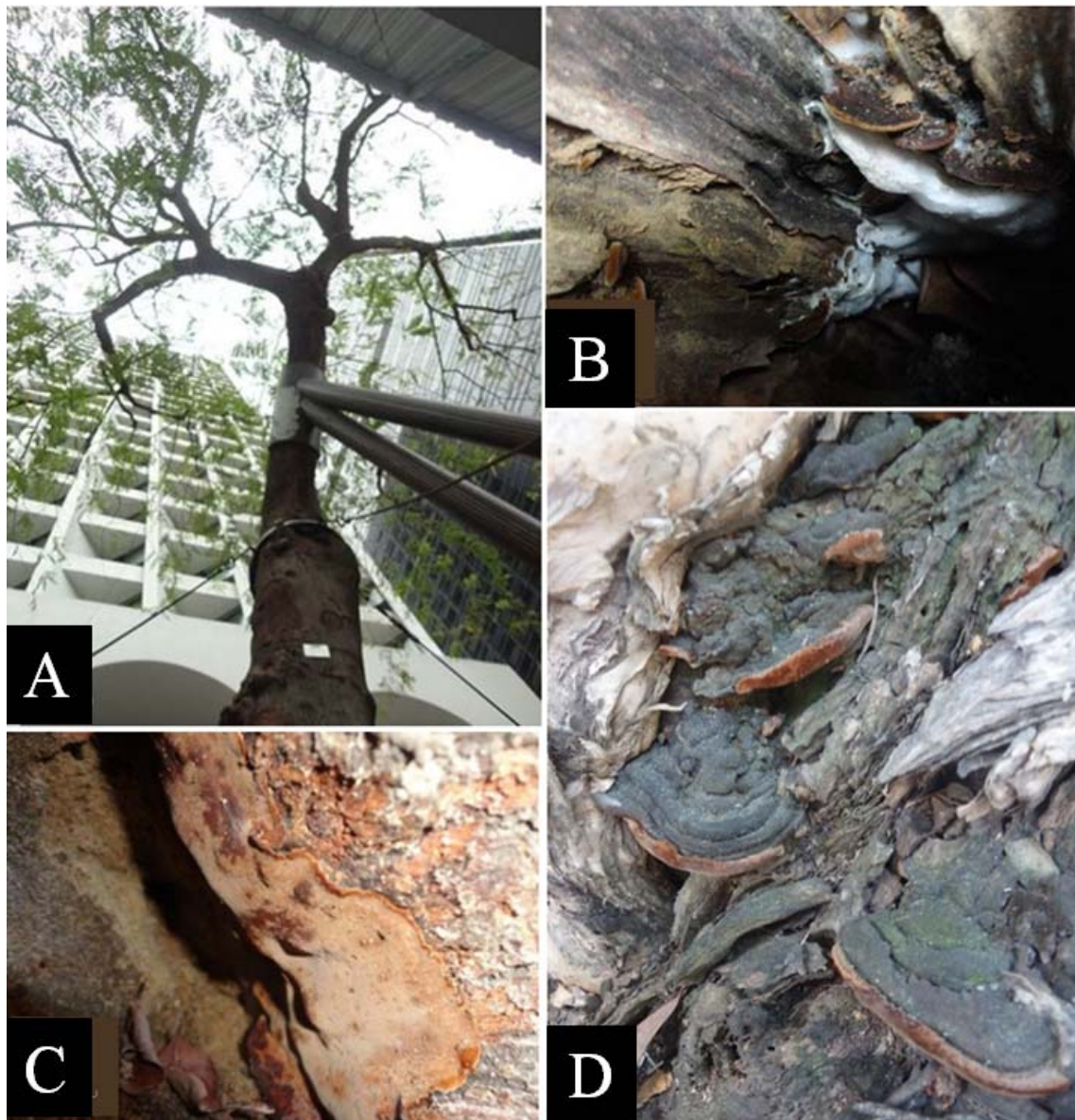
MANAGEMENT AND CONTROL

Risk category: High (RED)

Since this fungus could severely impact on the health and structural stability of the infected trees and there is currently no direct remedy for the BRR disease, removal of infected trees remains the most effective means to mitigate risk and control the spread of disease. Besides tree removal, all precautionary measures should be undertaken to prevent the spread of the disease to other healthy trees.

The 'Guidelines on Brown Root Rot Disease' issued by the Tree Management Office provides comprehensive information on the BRR disease and its management strategy, which is available at www.trees.gov.hk.

*Fuscoporia senex*²



(A) A *Cassia javanica* var. *indochinensis* colonised by *Fuscoporia senex*. (B) The fruiting bodies of *F. senex* in the cavity of *Sophora japonica*. (C) The fruiting bodies of *F. senex* located in the stem cavity of *Syzygium samarangense*. (D) The fruiting bodies of *F. senex* located on the stem cavity of *Melaleuca cajuputi* subsp. *cumingiana*.

² *Fuscoporia senex* (Nees & Mont.) Ghobad-Nejhad, *Mycotaxon* 101: 208 (2007). Index Fungorum and Mycobank as the two main fungal depositories hold different views on the taxonomy of this fungus. The former uses *Fuscoporia senex* as the current name while the latter uses *Phellinus senex*. *Fuscoporia senex* is adopted as the current name in this note.

FRUITING BODY

Fruiting bodies perennial, up to 3.5×8.5 cm and 2 cm thick, solitary, broadly attached to substrate, semicircular, convex, consistency coriaceous to woody hard; pilei surface first fulvous then brown to raw umber, finely velvety tomentose, narrow concentric sulcate zones with stiff, erect hairs, margin 1 mm thick, paler, obtuse, entire, context fibrous, glossy, dark blond to golden brown, a darker line above the tubes, 2 mm thick; pore surface fulvous then brownish grey, pores round and small, 10-11 per mm, layers up to 6 mm thick, margin sterile, fulvous; spores $4-6 \times 3-4$ μm , broadly ellipsoid, smooth, hyaline.

DISTRIBUTION AND HOST RANGE

Host trees recorded locally include *Albizia lebbbeck*, *Cassia javanica* var. *indochinensis*, *Melaleuca cajuputi* subsp. *cumingiana* and *Syzygium samarangense*.

SIGNS AND SYMPTOMS

There is not much information on the mode of infection for this species. Nevertheless, it is mostly observed on wounds and basal cavities on main trunks. Once entered through wounds, it may cause localised decay at first and move on to colonisation of deadwood. The presence of fruiting bodies on tree host is an obvious sign of advanced infection by this fungus. The infected trees may show non-specific symptoms such as crown defoliation, cavities and cracks at the advanced stage of infection.

PATHOLOGY

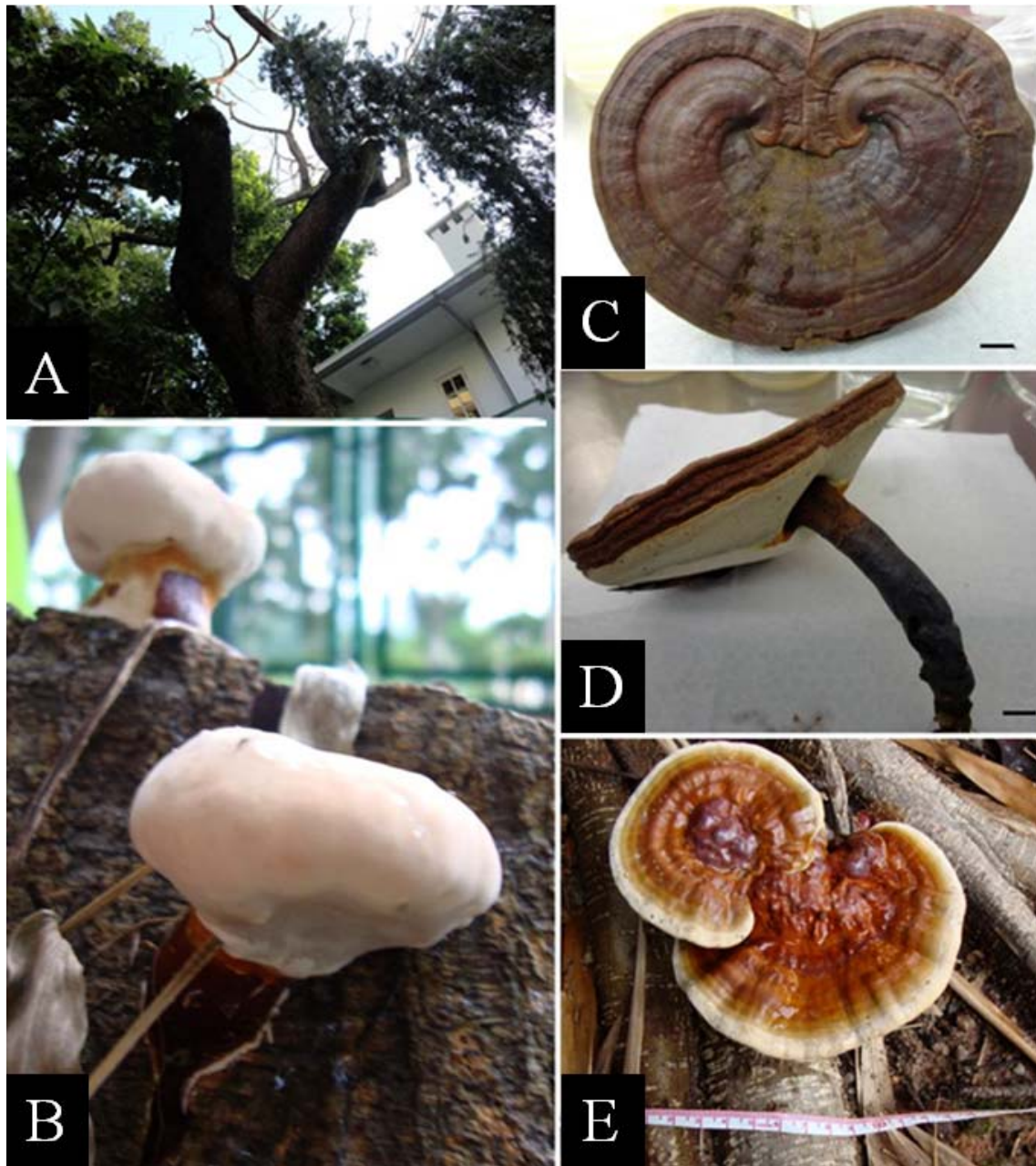
This fungus has a pantropical distribution range, including its presence in China. It could grow as a saprotrophic fungus on deadwood but could also act as a wound parasite causing white stringy rot in the heartwood of standing trees, particularly on stressed hosts.

MANAGEMENT AND CONTROL

Risk category: Moderate (ORANGE)

As this fungus is mainly associated with wounds and cavities of the main trunks and some structural branches, trees infected with this fungus should be monitored on a regular basis. Fruiting bodies of this fungus observed on trees should be removed to minimise the building-up of fungal inoculum. Fungicides may still be used as an interim measure for trees exhibiting early or advanced stage of infection, though the treatment may not be effective to hamper the onset of the disease. As wounds may serve as entry court for this fungus, trees should be avoided and minimised from injury arisen from large area pruning cut/mechanical damages as far as possible. At the advanced stage of infection in which the structural integrity of the trees is undermined and could not be mitigated through pruning and/or installation of props/wires, removal of structural limbs concerned and/or whole tree should be considered.

Ganoderma lucidum (broad sense)³



(A) *Albizia lebbbeck* infected by *G. lucidum*. (B) Immature fruit-bodies of *G. lucidum* on a wood stump. (C) A mature fruit-body of *G. lucidum*. Scale bars of C and D = 1cm. (D) Side-view of a fruit-body of *G. lucidum*. (E) Fruiting bodies of *G. lucidum* on a root of *Ficus microcarpa*.

³ *Ganoderma lucidum* (Curtis) P. Karst., *Revue Mycologique Toulouse* 3 (9): 17 (1881). Please note that *Ganoderma lucidum sensu lato* (broad sense) covers the species *Ganoderma lucidum* and *Ganoderma tropicum* within this complex that are commonly found in Hong Kong and could only be authenticated through micro-morphology, cultural characteristics and phylogenetic analysis.

FRUITING BODY

Fruiting bodies 2×4 cm to 4×8 cm in size and 1 cm to 3 cm in thickness; pilei reniform, flat, spongy, corky or woody when aged, yellowish-brown to red brown in colour, with a white margin, lacquer-like luster, striate, young or fresh fruiting bodies occasionally appeared as chunks of white mycelia-like masses on the stalks; stipes 7-15 cm long, 1-2.5 cm thick, lateral; pore surface white, with yellow patches sometimes, blood red to purple red when touched, pores round 5-6 per mm; spores $9-12 \times 4.5-7.5$ μ m, oval, brown.

DISTRIBUTION AND HOST RANGE

Ganoderma lucidum sensu lato (broad sense) infects broadleaved trees. Locally it is commonly found on *Acacia confusa* and *Ficus microcarpa*.

SIGNS AND SYMPTOMS

Ganoderma lucidum sensu lato (broad sense) is mainly associated with roots and root collar regions. Occasionally the lower trunks would also be affected. At the early stage of infection, no obvious abnormality could be observed in the tree crown, although fruiting bodies of the fungus may be present. As the infection continues, crown abnormality (e.g. sparse foliage density, small leave size, discolouration on leave, etc.) become obvious along with profuse formation of annual fruiting bodies on roots, root collar and lower trunk of the infected tree. Fruiting bodies are easily observable during wet season and withered, discoloured ones could also be observed in the dry season. At the time of sporulation, brownish yellow powdery spores could sometimes be found near the fruiting bodies.

PATHOLOGY

It is a pathogenic fungus causing white rot decay on trunks and roots, which can lead to tree death in a few years after infection, in particular, if the trees have been under stress.

MANAGEMENT AND CONTROL

Risk category: Moderate (ORANGE)

Since this fungus could adversely affect tree health and structural stability, infected trees should be put under regular monitoring. Fruiting bodies of this fungus observed on trees should be removed to minimise the risk of building up of fungal inoculum and infecting adjacent trees. Fungicides may still be used as an interim measure for trees exhibiting early or advanced stage of infection, though the treatment may not be effective to hamper the onset of the disease. At the advanced stage of infection in which the structural integrity of the trees is undermined and could not be mitigated through installation of props and wires, removal of structural limbs and/or whole tree should be considered.

*Ganoderma applanatum*⁴



(A), (B) and (C) Mature fruiting body of *Ganoderma applanatum* at the trunk.

⁴ *Ganoderma applanatum* (Pers.) Pat., Bulletin de la Société Mycologique de France 5: 67 (1889).

FRUITING BODY

Fruiting bodies perennial, 10-20 cm × 5-15 cm and 1.5-12 cm thick; pilei broadly rounded, hoof-shaped or irregularly shaped bracket, flat and directly attached to the substrate in clusters and tiers, cork-like to woody, grey turning into brown, upper surface forming an uneven crust, with ridges and concentrated furrows, covered by a thick chocolate brown to copper coloured layer of spore powder up to 1 mm thick, fresh fruiting bodies with white margin and slightly rounded, stalkless; pore surface white but becoming brown when damaged or with age, pores 4-5 per mm; spores 7.5-10 µm × 4.5-6.4 µm, oval, brown or yellowish brown.

DISTRIBUTION AND HOST RANGE

This fungus has a worldwide distribution and locally it could be found on broadleaved trees such as *Acacia confusa*, *Ficus microcarpa*, *Hibiscus tiliaceus* and *Sapium sebiferum*. Occasionally found on coniferous trees.

SIGNS AND SYMPTOMS

This fungus is mainly associated with roots and root collar of tree trunks, particularly on trees with obvious open wound and/or root damages. Trees with early stage of fungal infection by this fungus may experience stunted growth and non-specific symptoms on the crown such as defoliation and abnormal leaf size and colour. As the infection advances over time, crown symptoms may get worsen and accompanied by bark loosening at the infection zone.

Perennial fruiting bodies are often observed at the advanced stage of infection during which the fungus may have already been well-established by spreading vertically and radially along the trunk.

PATHOLOGY

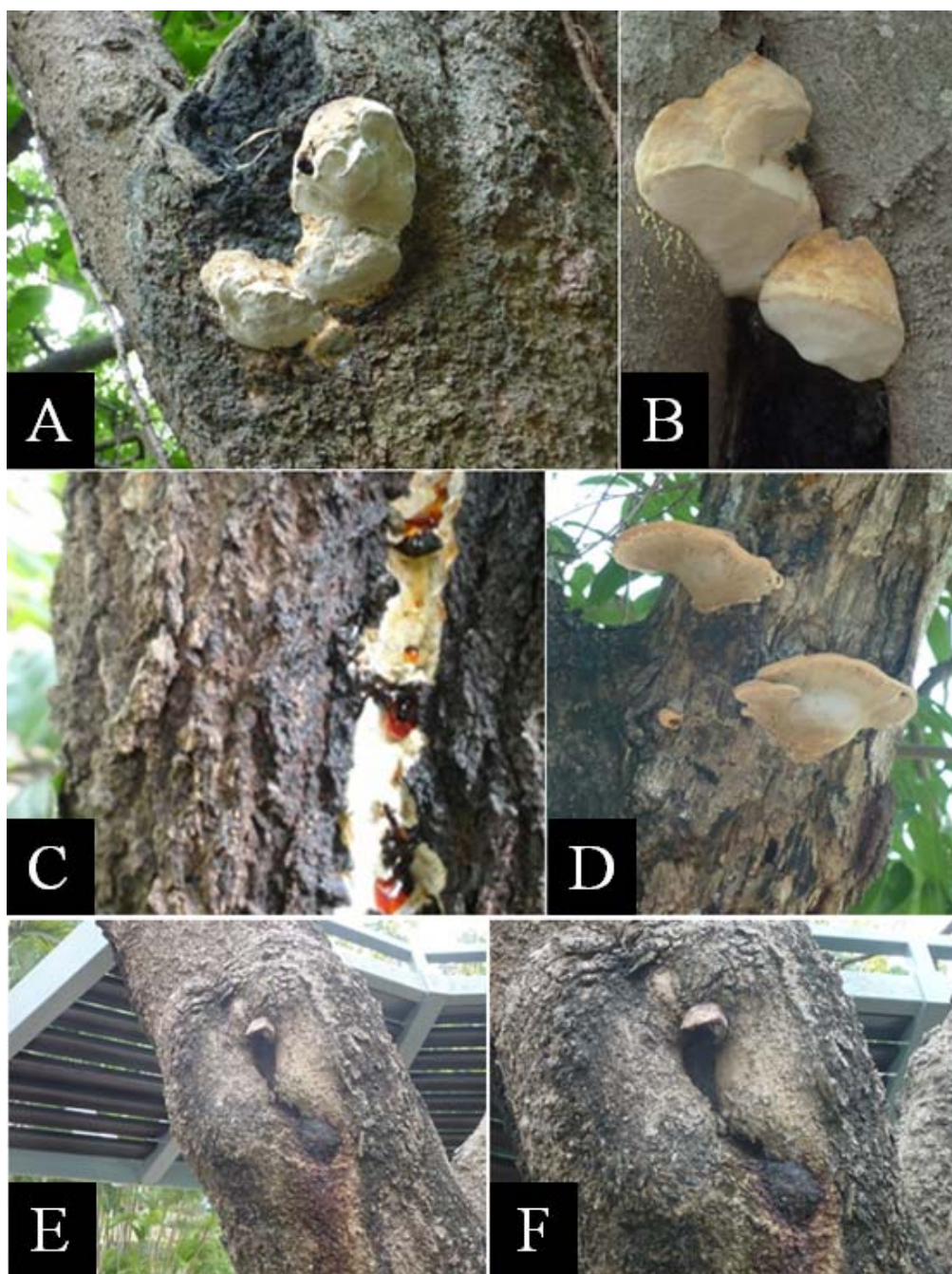
This white rot fungus is known for its capacity in impacting the health and structural stability of trees in the urban environment. Some experts view it as a predominantly saprotrophic fungus with the ability to degrade deadwood while others consider it as a pathogenic wood decay fungus with strong virulence owing largely to its association with extensive internal decay. Nevertheless, the ability of this fungus in colonising the heartwood and sapwood of trees substantiates the pathogenic nature of this fungus.

MANAGEMENT AND CONTROL

Risk category: Moderate (ORANGE)

Since this fungus could adversely affect tree health and structural stability, infected trees should be put under regular monitoring. As the disease may be disseminated through basidiospores, fruiting bodies observed should be removed to minimise the risk of building up of fungal inoculum in the infected trees. To reduce the chance of fungal infection, trees should be properly maintained and avoided from injury through pruning with large pruning wounds and/or large area mechanical damages. Fungicides may still be used as an interim measure for trees exhibiting early or advanced stage of infection, though the treatment may not be effective to hamper the onset of the disease. At the advanced stage of infection in which the structural integrity of the trees is undermined and could not be mitigated through installation of props and wires, removal of structural limbs and/or whole tree should be considered.

*Inonotus rickii*⁵



(A) Anamorph or asexual stage of *Inonotus rickii* (i.e. *Ptychogaster cubensis*) observed on the trunk of *Celtis sinensis*. (B) Anamorph of *I. rickii* (i.e. *P. cubensis*) near a canker of *Celtis sinensis*. (C) Immature fruiting bodies of *I. rickii* on a trunk. (D) Mature fruiting bodies of *I. rickii* on a decaying branch. (E) Senescent asexual fruiting bodies (*P. cubensis*) on a cavity of *Celtis sinensis*. (F) Close-up view of the senescent asexual fruiting bodies (*P. cubensis*).

⁵ *Inonotus rickii* (Pat.) D.A. Reid, Kew Bulletin 12 (1): 141 (1957).

FRUITING BODY

Sexual stage: fruiting bodies annual, up to 45 cm wide and 10 cm thick, sessile, attached to the substrate widely and firmly; pilei appanate to unguates, single to imbricate, at first soft and fleshy and then becoming firm, margin acute or obtuse, entire, undulate, upper surface golden brown and tomentose in younger parts, oldest parts dark rusty brown and rough, becoming rimose; pore surface pale brown, round to angular, 2-4 per mm; spores 6-8.5-(9) $\mu\text{m} \times 4.5\text{-}5.5 \mu\text{m}$, broadly ellipsoidal, thick-walled, golden yellow.

Asexual stage: asexual fruiting bodies (i.e. anamorph of *Inonotus rickii*, also named as *Ptychogaster cubensis*) semi-spherical or cushion shaped-like mass, soft and fleshy at first, velvety to the touch, yellowish brown to golden brown without the hymenial layer; becoming dark brownish and brittle, crumbling with the inner parts totally disintegrating to a mass of chlamydospores (i.e. thick-walled resting spores) when aged.

DISTRIBUTION AND HOST RANGE

This fungus has a worldwide distribution extending from tropical to temperate regions affecting trees in both the rural and urban settings. Locally, this fungus is found on broadleaved trees such as *Celtis sinensis*, *Cinnamomum camphora* and *Sapindus saponaria* along roadsides, on slopes and in parks.

SIGNS AND SYMPTOMS

As wounds serve as entry courts for this fungus, fruiting bodies are often found associated with pruning wounds and cankers on branches and main trunks. Most often, the semi-spherical/cushion shaped-like mass asexual fruiting bodies instead of the sexual fruiting bodies are observed emerging from branch stubs, pruning wounds, and cankers of the infected trees during rainy seasons. Later at the dry seasons as the asexual fruiting bodies age, they often turn dark-brownish and become senescent.

Similar to most wood decay fungi, early stage of fungal infection is not easily detected. As the infection progresses, the crown may exhibit non-specific symptoms such as defoliation, dieback and chlorosis. After establishment, the fungus starts causing localised decay and spread vertically and horizontally and cause internal decay. At the advanced stage after years of infection, crown dieback associated with structural weakness may eventually be experienced on the infected trees.

PATHOLOGY

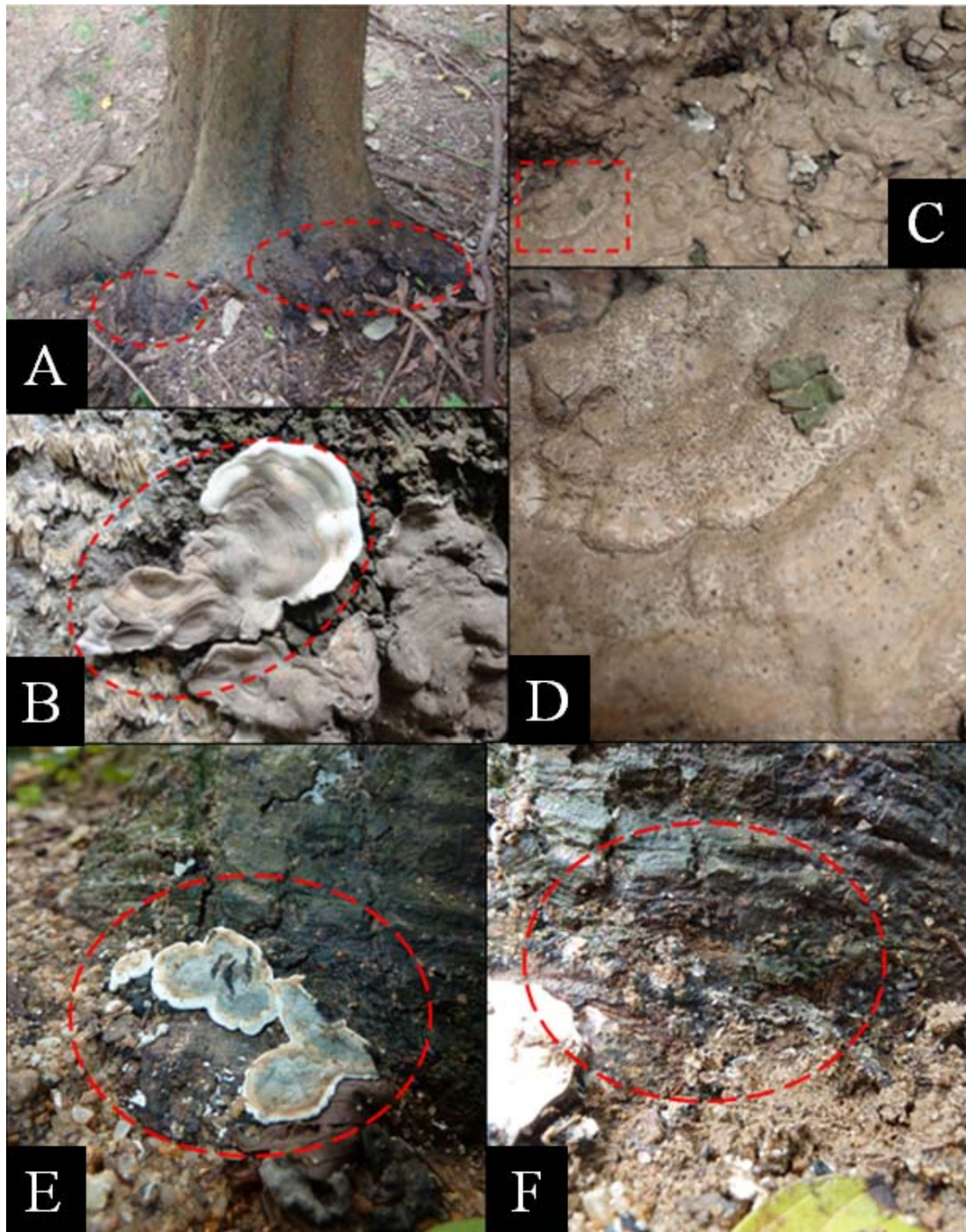
This white rot fungus is a well-documented canker causing pathogen with moderate virulence in Europe. It is able to cause decay on heartwood as well as sapwood and cambium on branches and trunks of trees resulting in eventual tree decline and mortality.

MANAGEMENT AND CONTROL

Risk category: Moderate (**ORANGE**)

Since this fungus would adversely affect tree health and structural stability, infected trees should be put under regular monitoring. Fruiting bodies of sexual stage (*Inonotus rickii*) and their asexual anamorphs (*Ptychogaster cubensis*) observed should be removed to minimise the building of fungal inoculum. Fungicides may still be used as an interim measure for trees exhibiting early or advanced stage of infection, though the treatment may not be effective to hamper the onset of the disease. To reduce the potential damage of this fungus, trees should be minimised from injury arisen from large area pruning cut/mechanical damages. At the advanced stage of infection in which the structural integrity of the trees is undermined and could not be mitigated through pruning/installation of props and wires, removal of structural limbs and/or whole tree should be considered.

*Kretzschmaria sandvicensis*⁶



(A) Fruiting bodies of *Kretzschmaria* sp. at a root collar of *Celtis sinensis*. (B) Primordial fruiting body of *K. sandvicensis* colonised on *C. sinensis*. (C) Mature fruiting bodies of *K. sandvicensis* colonised on *C. sinensis*. (D) Close-up of the mature fruiting body enlarged from C (the red square part). (E) Primordial fruiting body of *K. sandvicensis* colonised on *C. sinensis*. (F) Decaying tissue underneath the fruiting body in (E).

⁶ *Kretzschmaria sandvicensis* (Reichardt) J.D. Rogers & Y.M. Ju (1998).

FRUITING BODY

Stromata 1.5-7 cm in diameter, 2-3 mm thick, separated, aggregated or fused, attached to substrate with narrow connectives, with crenate margins, surface brown-coppery to dark brown, with reticulate cracks, immediately beneath surface carbonaceous, tissue between and beneath perithecia brown to dark brown; perithecia 1.3-1.8 mm high, 0.6-1.5 mm wide, globose to obovoid; ostioles papillate to finely papillate; asci 7-9 μm \times 3-4.5 μm , with apical ring bluing in Melzer's iodine reagent, urn-shaped; ascospores 33-43 μm \times 8-11 μm , unicellular, dark brown, fusiform to ellipsoid, inequilateral, smooth, germ slit straight, slightly less than or nearly equaling spore length.

DISTRIBUTION AND HOST RANGE

Kretzschmaria species have a worldwide distribution with *K. sandvicensis* occurring in the tropics. Locally, *K. sandvicensis* is found on *Celtis sinensis* and *Ficus microcarpa* along roadsides and in parks.

SIGNS AND SYMPTOMS

K. sandvicensis is found associated with roots and tree collar region of infected trees. Obvious symptoms may not be easily discerned on infected tree as infection is a slow process. During the advanced stage of infection, non-specific symptoms such as crown defoliation and cankers on lower trunk may be observed on infected trees. Both the primordial grayish leathery white margins fruiting bodies and the mature carbonaceous lumpy fruiting bodies (i.e. stromata), though inconspicuous, could be found on the roots and root collar regions of infected trees and served as readily available signs to confirm the presence of this fungus. Extensive decay of woody tissue could be observed underneath the locations where fruiting bodies are found.

PATHOLOGY

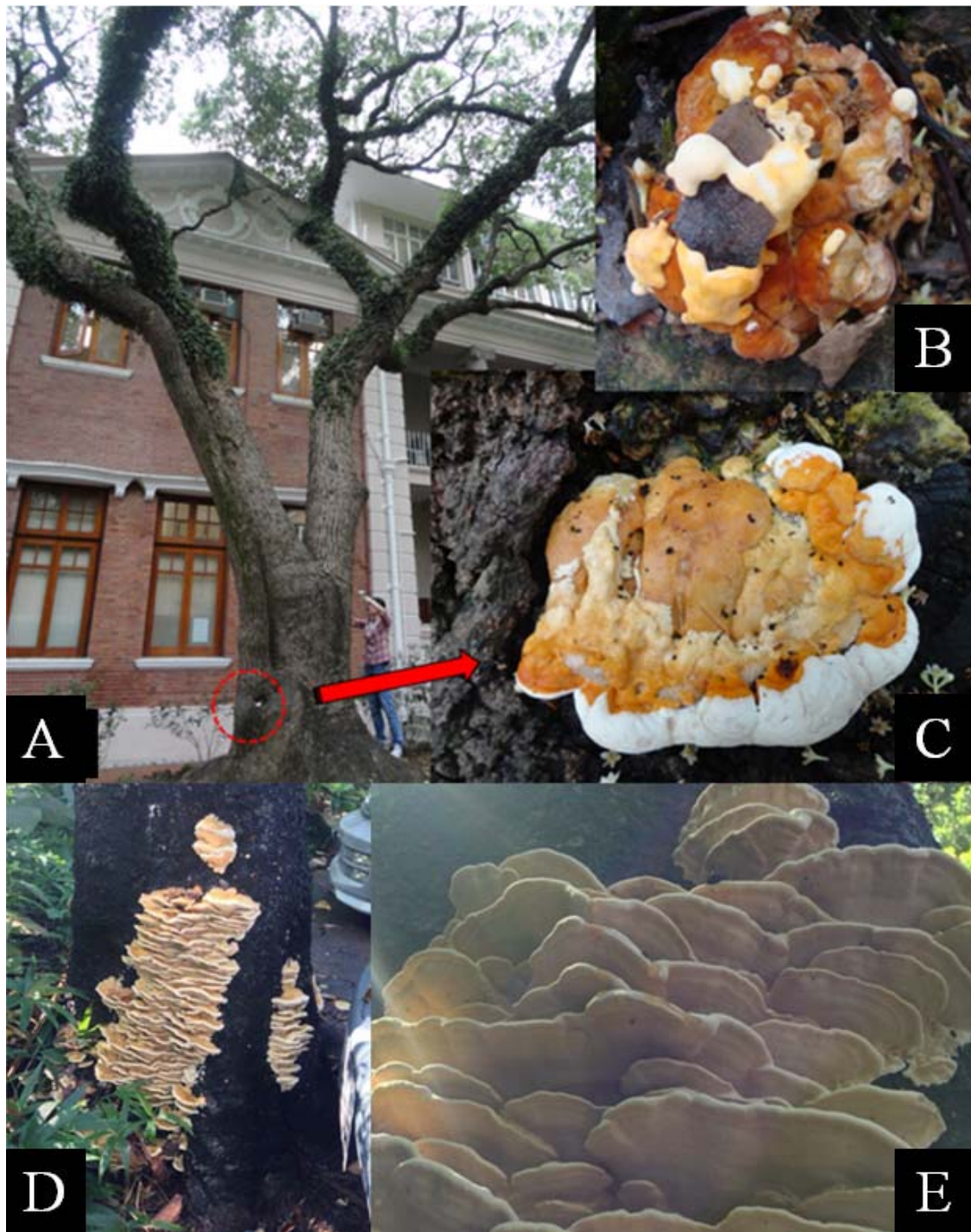
Kretzschmaria spp. cause soft and white rot decay on trees. This fungus could grow readily on woody substrata as a saprotrophic fungus but could act readily as a pathogenic fungus causing damages to sapwood and heartwood of living trees.

MANAGEMENT AND CONTROL

Risk category: Moderate (ORANGE)

Since this fungus would adversely affect tree health and structural stability, infected trees should be put under regular monitoring. As infection could be initiated through wounds, trees should be kept healthy and prevented from damages that would result in mechanical wounds of the lower trunk and the root systems. Fruiting bodies, if discernible and spotted should be removed to minimise the risk of building up of fungal inoculum and infecting adjacent trees. Fungicides may be used for trees exhibiting early or advanced stage of infection, though the treatment may not be effective to hamper the onset of the disease. At the advanced stage of infection in which the structural integrity of the trees is undermined and could not be mitigated through installation of props and wires, removal of structural limbs and/or whole tree should be considered.

*Rigidoporus ulmarius*⁷



(A) *Cinnamomum camphora* infected with *Rigidoporus ulmarius*. (B) Fruiting bodies of *R. ulmarius*. (C) Close-up of the fruiting bodies of *R. ulmarius* in (A). (D) Clusters of fruiting bodies of *R. ulmarius*. (E) The under-side of the fruiting bodies of *R. ulmarius*.

⁷ *Rigidoporus ulmarius* (Sowerby) Imazeki, Bulletin of the Government Forest Experimental Station Meguro 57: 97 (1952).

FRUITING BODY

Fruiting bodies up to 30 cm across, thick; pilei semi-circular, flat, hoof-shaped or irregular, woody yet pliable, upper surface cream-coloured, usually with green algal growth in older specimens; pore surface red-orange, fading to buff or dull pink with age, tube layers cinnamon brown in contrast to the paler flesh, pores 5-6 per mm; spores 5-7 μm , round, smooth-walled, hyaline.

DISTRIBUTION AND HOST RANGE

This fungus is mainly found in the tropical and subtropical regions but has also been reported in the temperate region. Locally, it is found in broadleaved trees such as *Celtis sinensis* and *Delonix regia*.

SIGNS AND SYMPTOMS

This fungus is mainly associated with root collars and lower trunks of infected trees. Like most wood decay fungi, symptoms associated with inception decay at the early stage of fungal infection is not easily detected. As the decay advances during the late stage of infection, non-specific symptoms such as crown defoliation and internal decay may be experienced on the infected trees. Fruiting bodies of this fungus serve as readily observable signs which occur individually or in aggregated forms on trunks.

PATHOLOGY

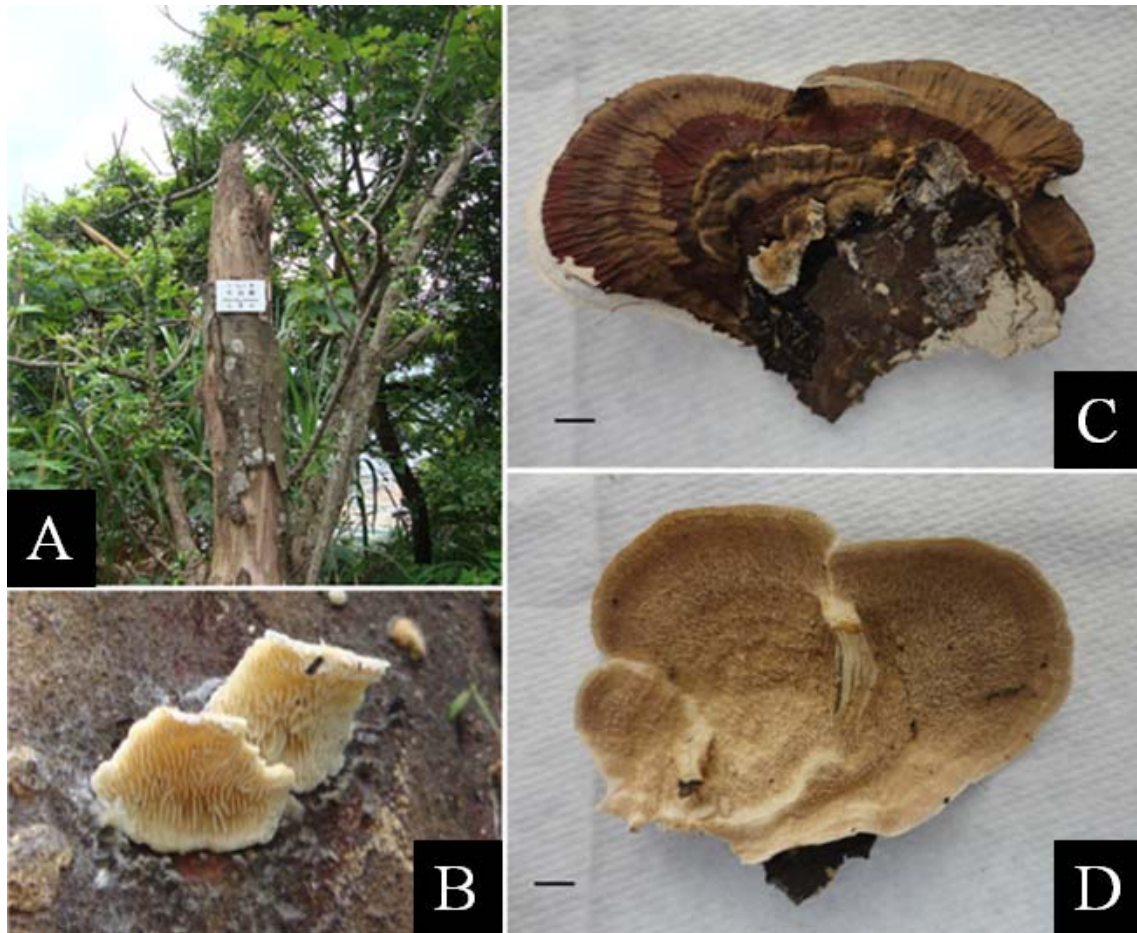
This fungus is a pathogenic wood decay fungus with the ability to cause white rot decay on the root collars and lower trunks. Trees after years of infection by this fungus would start experiencing decline as the fungus could gradually disrupt the function of vascular system in the sapwood and degrade the heartwood.

MANAGEMENT AND CONTROL

Risk category: Moderate (ORANGE)

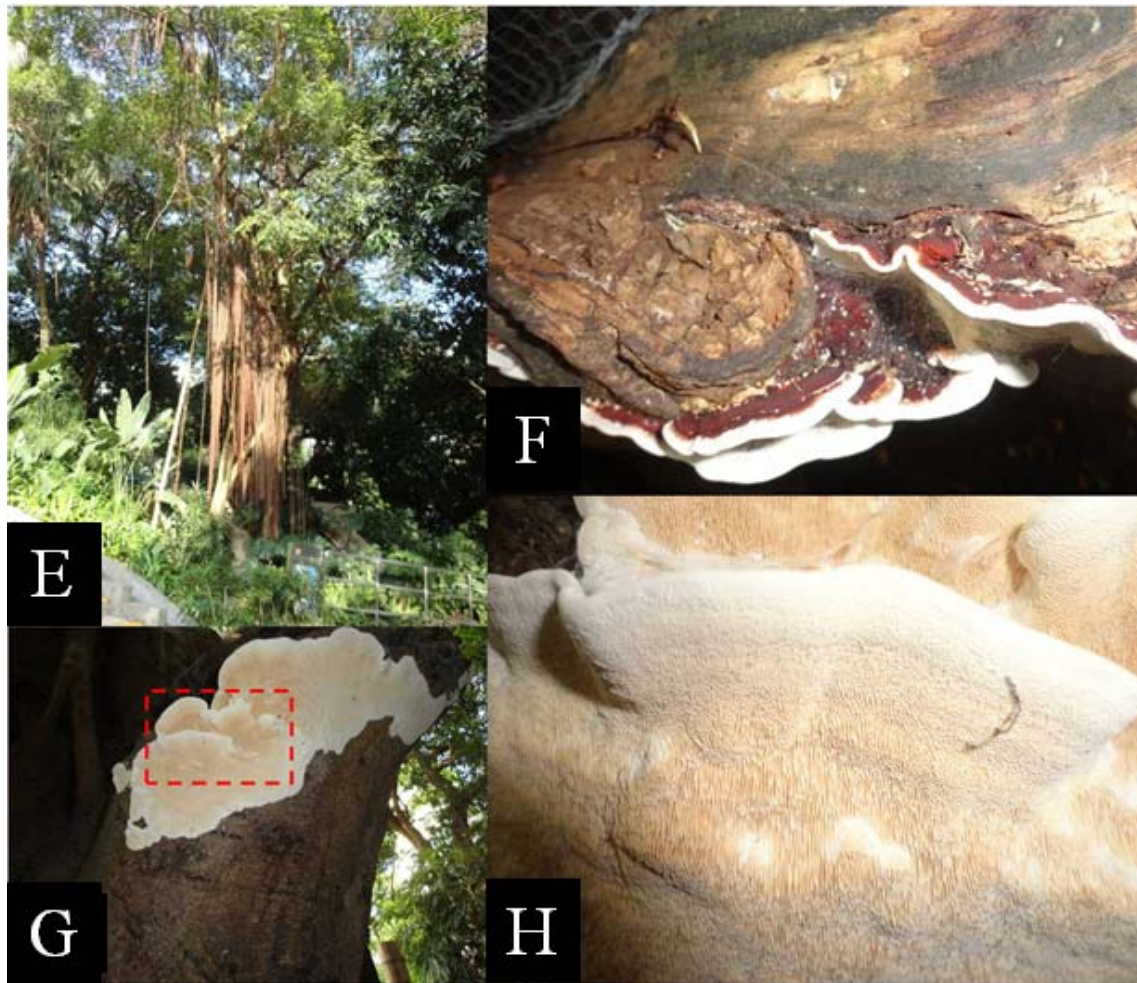
Since this fungus would adversely affect tree health and structural stability, infected trees should be put under regular monitoring. Avoidance of tree injury from pruning and mechanical damages could substantially reduce the chance of infection by this fungus as the main route of infection is from basidiospores. Fruiting bodies should be removed to minimise the risk of building up of fungal inoculum and infecting adjacent trees. Fungicides may be used for trees exhibiting early or advanced stage of infection, though the treatment may not be effective to hamper the onset of the disease. At the advanced stage of infection in which the structural integrity of the trees are undermined and could not be mitigated through pruning/installation of props and wires, removal of structural limbs and/or whole tree should be considered.

*Earliella scabrosa*⁸



(A) *Earliella scabrosa* on dead tree. (B) Young fruiting body of *E. scabrosa* on a dead tree. (C) and (D) Upper and underside of a mature fruiting body of *E. scabrosa* detached from on a fallen branch. Scale bars of C and D = 1cm.

⁸ *Earliella scabrosa* (Pers.) Gilb. & Ryvarden, Mycotaxon 22 (2): 364 (1985).



(E) *Ficus microcarpa* colonised by *Earliella scabrosa*. (F) Surface of the fruiting body of *E. scabrosa*. (G) The underside of the fruiting body of *E. scabrosa* showing the hymenium layer. (H) Enlarged picture showing the pores from C (indicated with red rectangular).

FRUITING BODY

Fruiting bodies sessile, resupinate or laterally attach to wood surface; pilei 1×2 cm to 4×6 cm in size, bracket-shaped, grow in bunches, tough and coriaceous, white at early stage, later covered with red or red-brown layer of cutin with white margin; pore surface white to cork coloured, 2-3 per mm, irregular shaped; spores $8-12.5 \mu\text{m} \times 3.5-5 \mu\text{m}$, cylindrical to oblong ellipsoid, hyaline.

DISTRIBUTION AND HOST RANGE

This fungus is mainly found in the tropical region and associated with broadleaved trees such as *Acacia* spp., *Ficus microcarpa* etc. as well as on dead/dying trees locally in urbanised setting along roadsides, on slopes and in parks. It is also found associated with surface of pruning wounds on braches and damaged areas on the tree trunks.

SIGNS AND SYMPTOMS

As wounds serve as entry courts for this fungus, fruiting bodies could be observed on pruning wounds and damaged tissues on branches and tree trunks. This fungus is likely to cause localised decay on tree. Most often trees observed with this fungus are already weakened with non-specific symptoms of crown abnormality such as defoliation, dieback and small leave size, etc.

PATHOLOGY

This fungus is reported as a saprotrophic fungus on deadwood and causing white rot decay, but its ability to associate with exposed living tissues (sapwood) on the main trunk of weakened tree hosts reveals the weakly pathogenic nature of this fungus with low virulence. Further to the degradation by this fungus, the infected trees may be subject to attack by other opportunistic fungal pathogens.

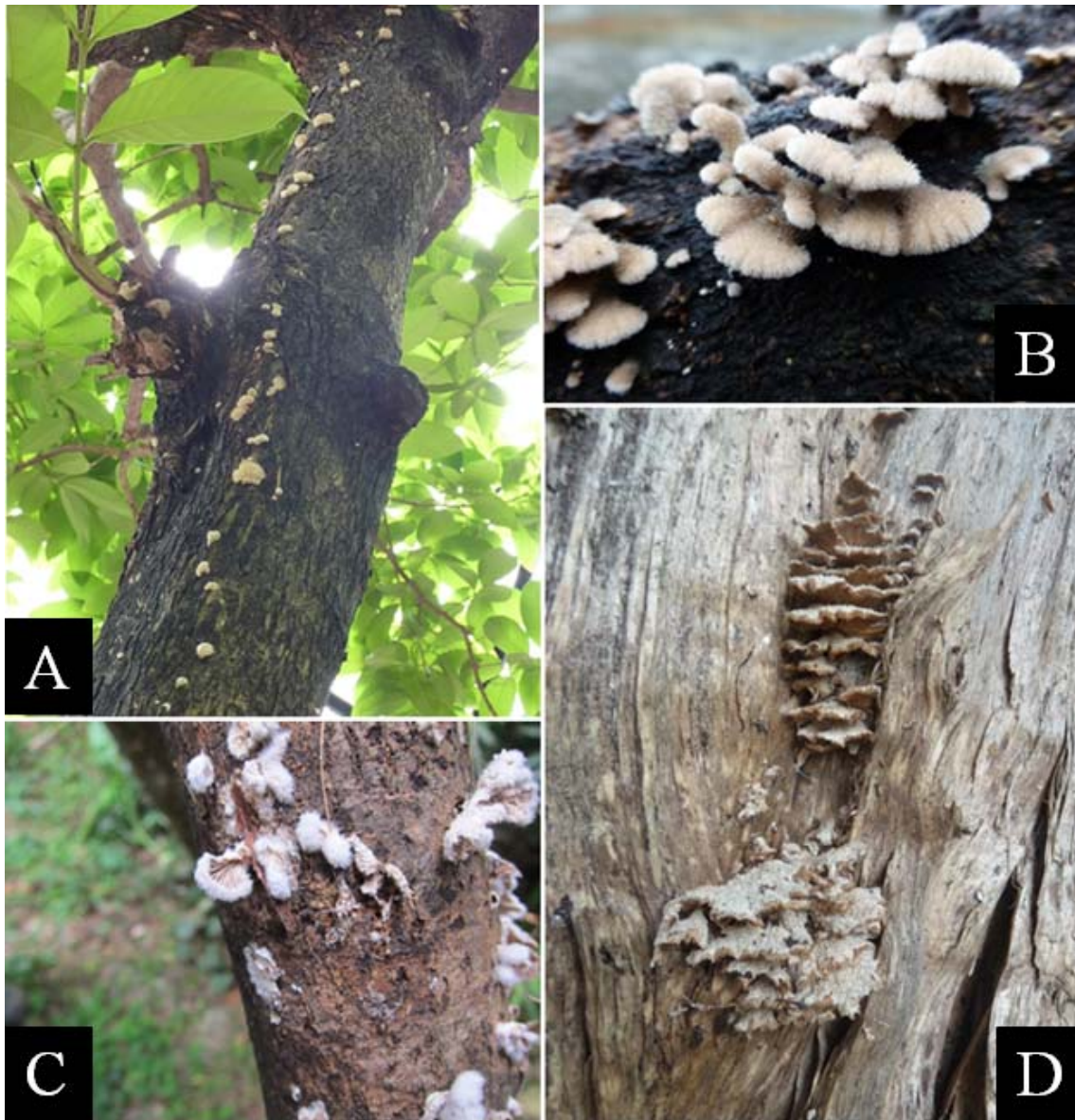
MANAGEMENT AND CONTROL

Risk category: Low (YELLOW)

Since this fungus may aggravate the health and structural stability of weakened trees, infected trees should be put under monitoring if the fungus is associated with the main trunk and major branches of stressed trees. For trees observed with this fungus on small branches, the defective part should be removed. Fruiting bodies observed on trees should be removed to minimise building-up of fungal inoculum. Fungicides may be applied on the trees as an interim measure to retard fungal growth.

As there are occasions where trees detected with *Earliella scabrosa* are also infected with some other pathogenic root rotting fungi such as *Phellinus noxius* and *Ganoderma* spp., it is advisable to check the root and root collar regions of the host trees for the presence of other pathogenic root rotting fungi. As wounds may serve as entry courts for this fungus, trees should be avoided and minimised from injury arisen from large area pruning cut/mechanical damages.

*Schizophyllum commune*⁹



(A) Fruiting bodies of *Schizophyllum commune* colonised the bark of *Lagerstroemia speciosa*. (B) The upper surface of fruiting bodies of *S. commune*. (C) The lower surface of the fruiting bodies of *S. commune*. (D) Senescent fruiting bodies of *S. commune* on a dead tree trunk.

⁹ *Schizophyllum commune* Fr., Systema Mycologicum 1:330 (1821).

FRUITING BODY

Fruiting bodies (pilei) 1-3(5) cm in diameter, round, fan-shaped or kidney-shaped, flesh hard, becoming thin and elastic when wet, and fragile under dry conditions, outer surface felted, wavy, slightly lined, with white, grey-white or pale orange areas, margin curling inwards, either split or lobed, stemless, simply sitting on the substrate; spores 5-5.5 μ m \times 2 μ m, oblong, hyaline.

DISTRIBUTION AND HOST RANGE

This fungus has a worldwide distribution and has a very broad host range. Locally, it could be observed on broadleaved trees such as *Acacia* spp., *Celtis sinensis* and *Lagerstroemia speciosa* along roadsides, on slopes and in parks.

SIGNS AND SYMPTOMS

Wounds from pruning cuts as well as injury arisen from low temperature and sunscald damages could readily serve as entry courts for this fungus. As such, it is often found associated with wounded barks and cankers on branches and trunks of trees. Once established on infected trees, localised decay may proceed and pave the way for further infection by other opportunistic wood decay fungi. Most trees observed with the presence of this fungus are usually already weakened and exhibit non-specific symptoms of tree crown abnormality such as defoliation, dieback and small leave size etc.

PATHOLOGY

This white rot fungus is regarded as a saprotrophic fungus with the ability to recycle deadwood but may also cause damages on weakened trees as a pathogenic fungus with weak virulence. It is therefore regarded as a wound parasite having the ability to cause wood decay on injured cambium/sapwood and exposed heartwood.

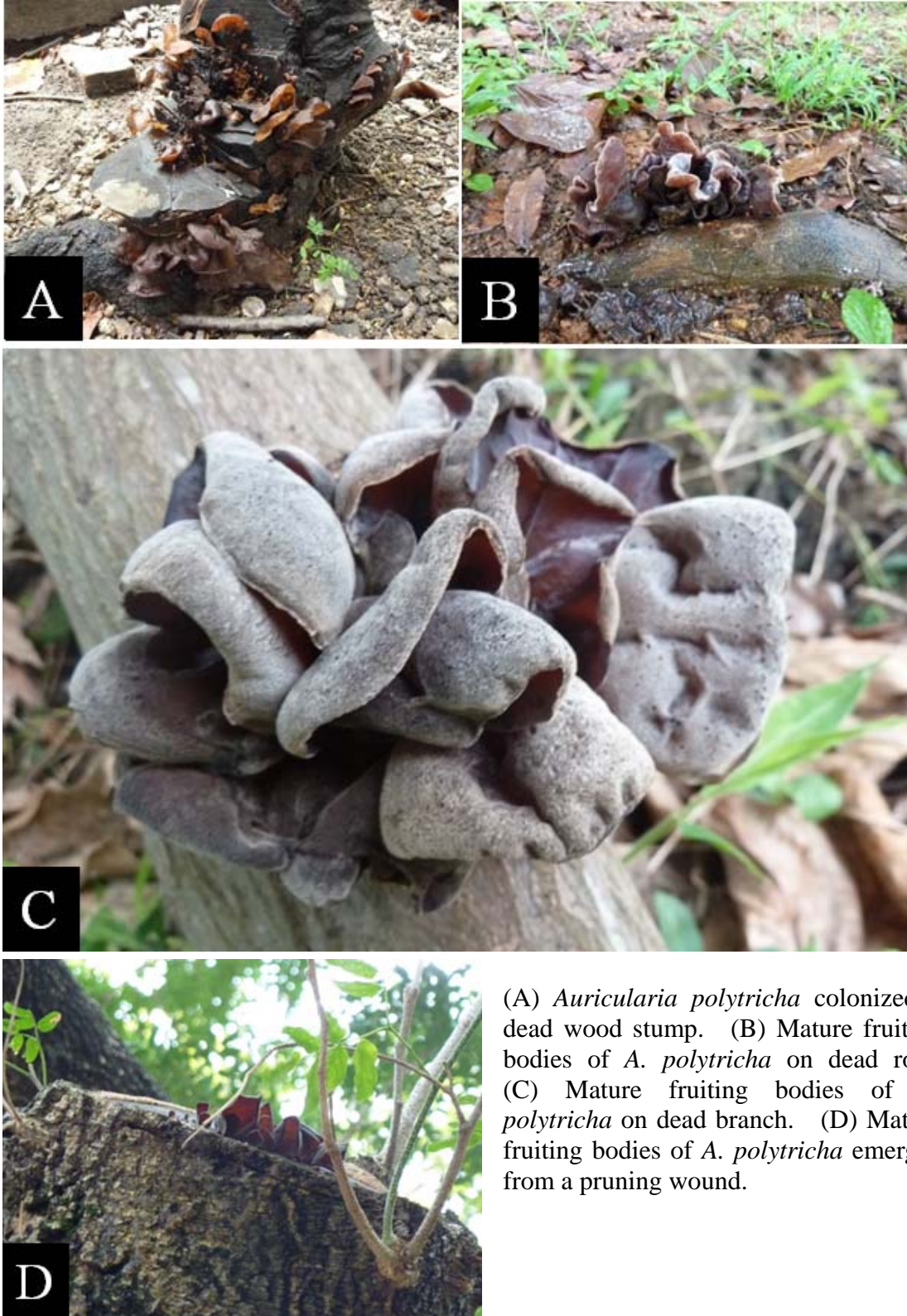
MANAGEMENT AND CONTROL

Risk category: Low (YELLOW)

Since this fungus may affect the health and structural stability of trees, mitigation measures should be exercised depending on tree conditions and the location at which the fungus is observed. Trees infected with this fungus should be put under monitoring only if the fungus is associated with the main trunk or structural branches of trees. Alternatively, removal of the defective parts could be considered if the fungus is observed on small size branches with weak attachment. Fungicides may be applied on trees infected with this fungus as an interim measure to retard fungal growth.

It is worthy to note that as fruiting bodies of this fungus are relatively small, they may not be easily detected. As such, one should carefully examine for sign of this fungus, particularly in wounded areas of the trees during inspection. By increasing tree vigour through proper tree care regimes and minimising tree damage from pruning cuts, the chance of fungal infection would be substantially reduced.

*Auricularia polytricha*¹⁰



(A) *Auricularia polytricha* colonized a dead wood stump. (B) Mature fruiting bodies of *A. polytricha* on dead root. (C) Mature fruiting bodies of *A. polytricha* on dead branch. (D) Mature fruiting bodies of *A. polytricha* emerged from a pruning wound.

¹⁰ *Auricularia polytricha* (Mont.) Sacc., Atti dell'Istituto Veneto Scienze 3:722 (1885).

FRUITING BODY

Fruiting bodies annual, 4-16 cm wide, resupinate or pileate, loosely attached, laterally and sometimes by a very short stalk, elastic, gelatinous, hymenium smooth, or wrinkled, pale brown to dark brown to blackish brown with a whitish boom, sterile surface dark yellowish brown to dark brown with greyish brown bands, hairy, silky; hairs up to 0.6mm long, thick-walled; basidia $46-60\mu\text{m} \times 4-5.5\mu\text{m}$, cylindrical, hyaline, 3-septate, with 1-3 lateral sterigmata; spores $13-16\mu\text{m} \times 4-5.5\mu\text{m}$, reniform to allantoid, hyaline, guttulate.

DISTRIBUTION AND HOST RANGE

This fungus is widely distributed throughout the world. Locally, it is found on broadleaved trees, such as *Acacia confusa*, *Aleurites moluccana*, *Celtis sinensis* and *Ficus microcarpa* in urbanised setting along roadsides, on slopes and in parks.

SIGNS AND SYMPTOMS

This fungus is found associated with surface of pruning wounds, dying and dead branches as well as dead trees. Fresh pruning cuts and dying/dead branches with defoliation are locations to observe for the fungus. Fruiting bodies serve as obvious sign for this species.

PATHOLOGY

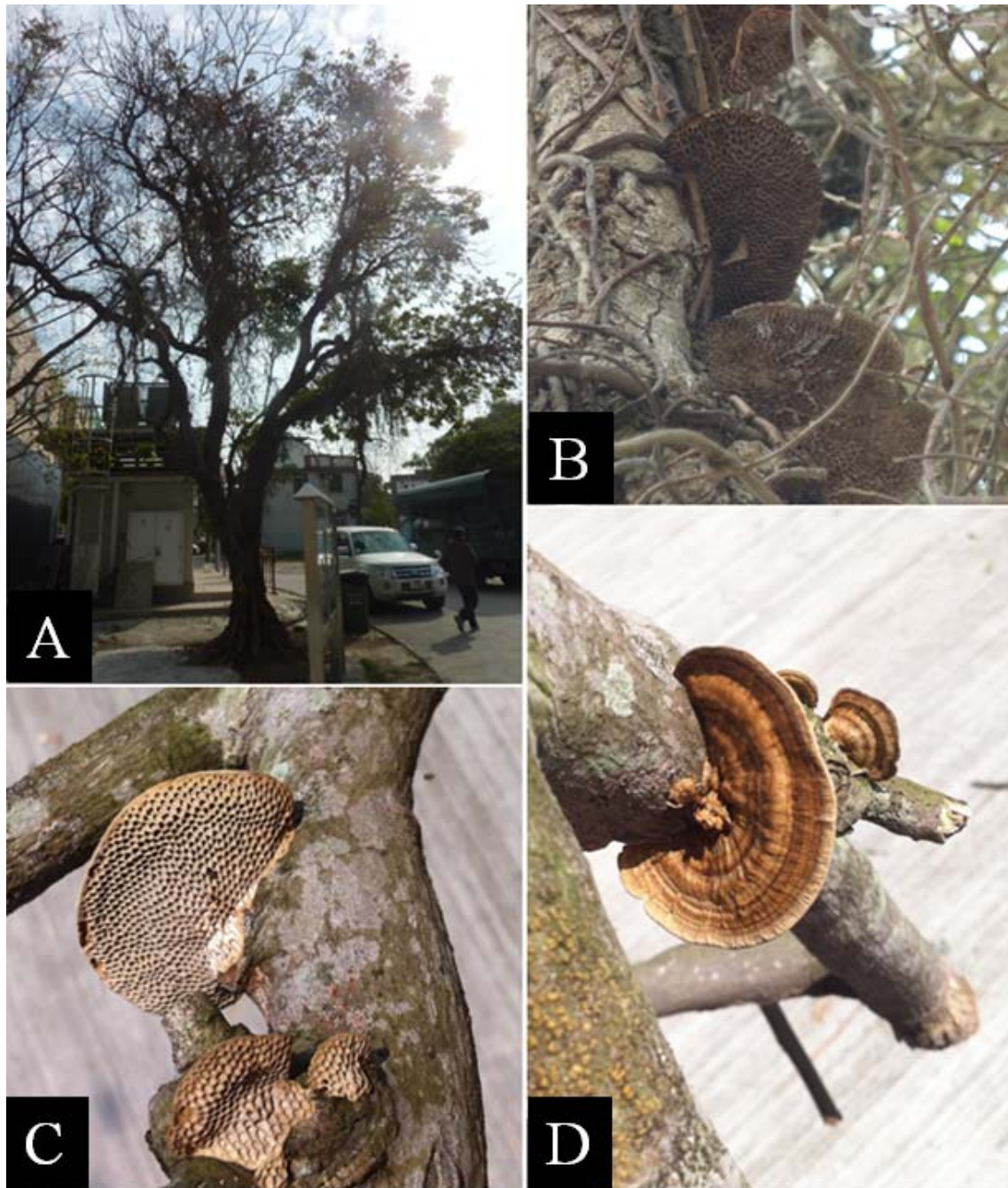
It is a saprotrophic fungus with the ability to cause white rot decay on dead and decaying wood tissue.

MANAGEMENT AND CONTROL

Risk category: Insignificant (**GREEN**)

Although there is insignificant concern on tree health and structural stability due to the presence of this fungus, the trees should be checked for the presence and extent of localised decay in the region where fruiting bodies are observed. Branches with weak attachment observed with sign of this fungus should be removed.

*Hexagonia tenuis*¹¹



(A) Dead branches of a *Dimocarpus longan* were colonised by *Hexagonia tenuis*. (B) Mature fruiting bodies of *H. tenuis* on a dead branch of the *D. longan*. (C) Mature fruiting bodies of *H. tenuis* (upper-side) on dead log. (D) Mature fruiting bodies of *H. tenuis* (under-side) on dead log.

¹¹ *Hexagonia tenuis* (Hook.) Fr., *Epicrisis Systematis Mycologici*: 498 (1838).

FRUITING BODY

Fruiting bodies (pilei) annual to perennial, 3-5 cm × 4-8 cm and 0.2 cm thick, solitary or in clusters, pileate, flabelliform to semi-circular bracket, broadly or narrowly attached to the substrate or almost stipitate, thin, flexible and coriaceous when dry, upper surface concentrically zoned, ochraceous to dark brown; pore surface with grayish to ashy bluish tint, pores angular to hexagonal, very variable, mostly 2 per mm; spores ellipsoidal, smooth-walled hyaline.

DISTRIBUTION AND HOST RANGE

This fungus has a worldwide distribution. Locally it is commonly found on broadleaved trees such as *Delonix regia*, *Ficus microcarpa* and *Dimocarpus longan* in urbanised setting along roadsides, on slopes and in parks.

SIGNS AND SYMPTOMS

Fruiting bodies of this fungus are mainly found on dying/dead branches, dead trees as well as aged pruning cuts.

PATHOLOGY

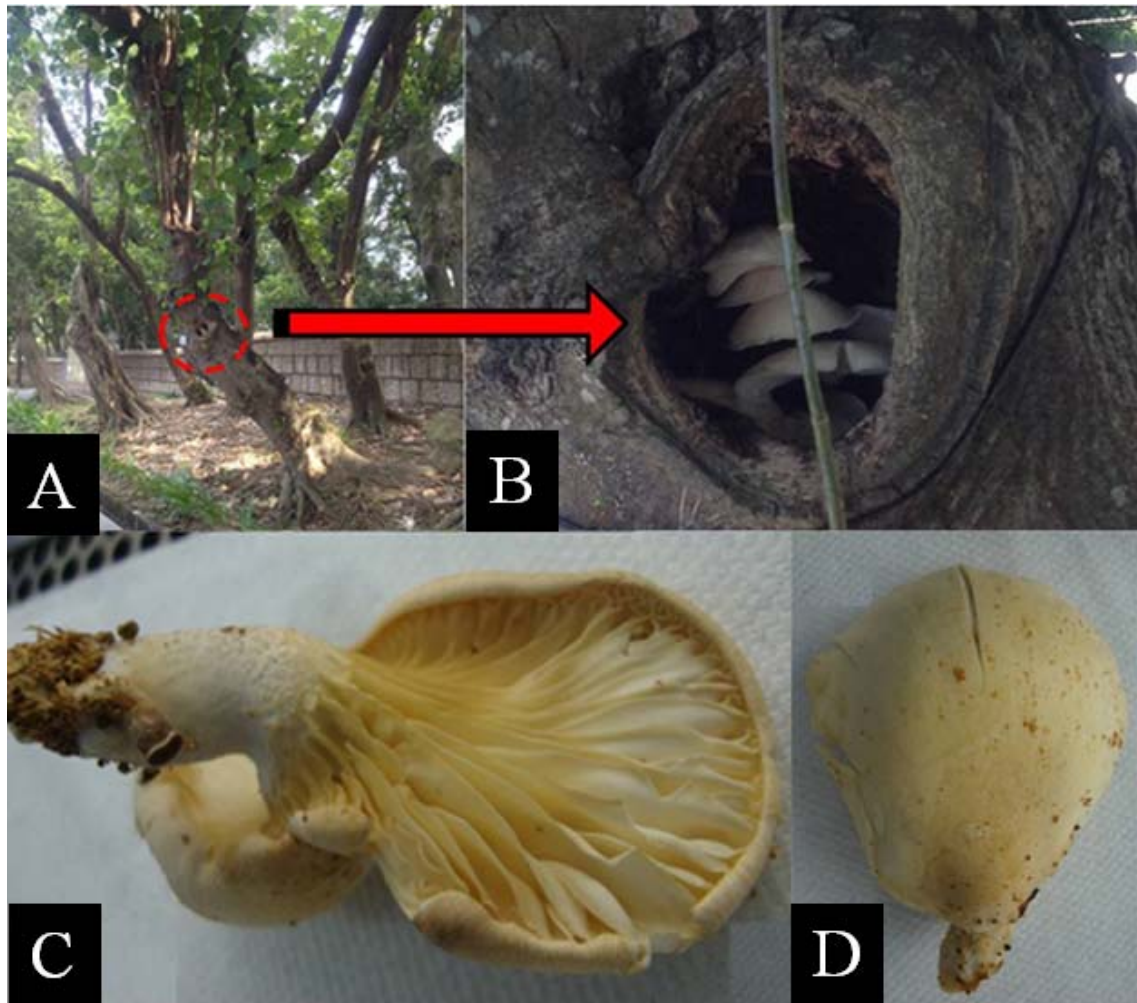
It is a saprotrophic fungus with the ability to cause white rot decay on dead and decaying wood tissue.

MANAGEMENT AND CONTROL

Risk category: Insignificant (GREEN)

Although there is insignificant concern on tree health and structural stability due to the presence of this fungus, the trees should be checked for the presence and extent of localised decay in the region where fruiting bodies are observed. Dead branches and branches with weak attachment observed with sign of this fungus should be removed.

*Pleurotus cystidiosus*¹²



(A) *Pleurotus cystidiosus* in the cavity of a *Hibiscus tiliaceus*. (B) Close-up of the fruiting bodies of *P. cystidiosus* in (A). (C) The under-side of the fruiting body of *P. cystidiosus*. (D) The upper-side of the fruiting body of *P. cystidiosus*.

¹² *Pleurotus cystidiosus* O.K. Mill., Mycologia 61: 889 (1969).

FRUITING BODY

Fruiting bodies up to 9.0 cm in height, pleurotoid; pilei up to 10.5 cm in diameter, depressed, surface grayish brown bearing brownish to purplish squamules, dry, fleshy, flesh up to 0.3 cm thick, white, lamellae yellowish white, decurrent, extending down on to the stipe, subdistant (up to 0.4 cm apart from each other), unequal, divided into two tiers, ventricose, gill edges wavy, spore print white; stipe 4.5 to 6.5 cm long, 2.2 to 3 cm broad, grayish brown, lateral, tapering downwards, solid, flesh white underneath; basidia $33.0\text{-}50.0 \times 5.0\text{-}8.3 \mu\text{m}$; spores $8.5\text{-}14.5 \times 4.5\text{-}6.64 \mu\text{m}$, oblong, elliptical, inamyloid.

DISTRIBUTION AND HOST RANGE

This fungus is mainly found in the tropical and subtropical regions. Locally, it is found in broadleaved trees such as *Hibiscus tiliaceus* etc.

SIGNS AND SYMPTOMS

This fungus is found associated with wounds, cavities, dying and dead branches as well as dead trees. Fresh pruning cuts, exposed wood and dying/dead branches with defoliation are locations to observe for the fungus. Fruiting bodies serve as obvious sign for the presence of this saprotrophic fungus on trees.

PATHOLOGY

It is a saprotrophic fungus with the ability to cause white rot decay on dead and decaying wood tissue.

MANAGEMENT AND CONTROL

Risk category: Insignificant (**GREEN**)

Though there is insignificant concern on tree health and structural stability due to the presence of this fungus, the trees should be checked for the presence and extent of localised decay in the region where fruiting bodies are observed. Dead branches and branches with weak attachment observed with sign of this fungus should be removed.

4. REFERENCES

- Ann, P.J., Chang, T.T. and Ko, W.H. (2002). *Phellinus noxius* Brown Root Rot of fruit and ornamental trees in Taiwan. *Plant Disease*, 86,820-826.
- Annesi, T., D'amico, L., Bressanin, D., Motta, E. and Mazza, G. (2010). Characterization of Italian isolates of *Inonotus rickii*. *Phytopathologia Mediterranea*, 49(3),301-308.
- Atri, N.S., Sharma, S.K., Kaur, N., Rahi, P. and Gulati, A. (2012). Morpho-Cultural, Molecular and Nutraceutical Studies on *Coremiopleurotus* from India. *World Applied Science Journal*, 17(6),759-763.
- Barnard, E.L. (1993). *Inonotus rickii* (Anamorph: *Ptychogaster cubensis*): A wood-decaying fungus of importance to Florida hardwoods. Florida Department of Agriculture and Consumer Services, Division of Plant Industry *Plant Pathology Circular*. No. 357,3pp.
- Barnard, E.L. and Smith, J.A. (2011). *Understanding decay in Florida trees: An explanation and pictorial guide to some of the more common decay fungi observed on Florida Trees*. Florida Division of Forestry. 8pp.
- Chang, S.T. and Mao X.L. (1995). *Hong Kong Mushrooms*. The Chinese University Press, Hong Kong.
- Chang, T.T., Hsieh, H.J., Chang, R.J. and Fu, C.S. (1999). *Common tree diseases in Taiwan*. Taiwan Forestry Research Institute. Taipei.204pp.
- Dai, Y.C., Cui, B.K., Yuan, H.S. and Li, B.D. (2007). Pathogenic wood-decaying fungi in China. *Forest Pathology*, 37,105-120.
- Ding, S. (2013). *A survey of fungi associated with trees in subtropical Hong Kong*. (Unpublished M.Phil. dissertation). The University of Hong Kong, Hong Kong.
- Griffiths, D.A. (1977). *Fungi of Hong Kong*. Urban Council, Hong Kong.
- Hayes, E. (2001). *Evaluating tree defects* (2nd Edition.). Safetrees, LLC., Rochester.

- Hodges, C.S. and Tenorio, J.A. (1984). Root disease of *Delonix regia* and associated tree species in the Mariana Islands caused by *Phellinus noxius*. *Plant Disease*, 68,334-336.
- Jan, Y., Jang, S., Lim, Y.W., Lee, J.S. and Kim, J.J. (2012). Four unrecorded wood decay fungi from Seoul in Korea. *Mycobiology*, 40(3),195-201.
- Ko, W.H. (2009). Nature of slow and quick decline of macadamia trees. *Botanical Studies* 50,1-10.
- Lee, S.S. and Jung, H.S. (2006). Taxonomic study on Korean Aphyllophorales (5) – on some unrecorded genera and species. *Mycobiology*, 34(4),166-175
- Luley, C.J. (2005). *Wood Decay Fungi Common to Urban Living Trees in the Northeast and Central United States*. Urban Forestry LLC, Naples.
- Melo, I., Ramos, P. and Caetano, M.F.F. (2002). First Record of *Inonotus rickii* (Basidiomycetes, Hymenochaetaceae) in Portugal. *Portugaliae Acto Biologica*, 20,265-269.
- Recio Herrera, G.M. and Maldonado González, S.G. (2014). A revision of the genus *Kretzschmaria* (Ascomycota, Xylariaceae) in Cuba. *Willdenowia*, 44,57-64.
- Rodriguez, C., Burdsall, H. and Volk, T.J. (1995). Wood-decay basidiomycetes from the state of Bolivar in Southeastern Venezuela. *Mycotaxon*, 57,377-389.
- Schwarze, F.W.M.R. (2008). *Diagnosis and Prognosis of the Development of Wood Decay in Urban Trees*. ENSPEC Pty Ltd, Australia.
- Schwarze, F.W.M.R., Engels, J. and Mattheck, C. (2000). *Fungal strategies of wood decay in trees*. Springer-Verlag Berlin Heidelberg, Germany.
- Sinclair, W.A. and Lyon, H.H. (2005). *Disease of Trees and Shrubs* (2nd Edition.). Cornstock Publishing Associates, Ithaca, NY.
- Sharma, R.C. and Sharma, J.N. (2005). *Challenging problems in horticultural and forestry pathology*. Indus Publishing Company, New Delhi.
- Stancheva, Y., Bencheva, S., Pavlidis, T. and Ilieva, M. (2009). *Atlas of wood decaying fungi*. Pensoft Publishers, Bulgaria.

- Takemoto, S., Nakamura, H., Imamura, Y., and Shimane, T. (2010). *Schizophyllum commune* as a Ubiquitous Plant Parasite. *Japan Agricultural Research Quarterly*, 44(4),357-364.
- Terho, M., Hantula, J. and Hallaksela, A.M. (2007). Occurrence and decay patterns of common wood-decay fungi in hazardous trees felled in the Helsinki City. *Forest Pathology*, 37,420-432.
- Tzean, S.S., Hsieh, W.H., Chang, T.T., Wu, S.H. (2005). *Fungal flora of Taiwan* (1st Edition.). National Science Council, Executive Yuan, Taiwan (R.O.C.). 2422pp.
- Watson, G. and Green, T. (2011). *Fungi on Tree – An Arborists' Field Guide*. The Arboriculture Association, UK.
- You, W.T. and Lin, Y.L. (2010). Wood-inhabiting macrofungi of the experimental forest of Nation Ilan University. *Ilan University Journal of Bioresources*, 6(1),1-7.
- Zhou, L.W., Cao, Y., Wu, S.H., Vlasák, J., Li, D.W., Li, M.J. and Dai, Y.C. (2014). Global diversity of the *Ganoderma lucidum* complex (Ganodermataceae, Polyporales) inferred from morphology and multilocus phylogeny. *Phytochemistry*. In press.
- 周文能、張東柱 (2004). 野菇圖鑑:台灣四百種常見大型真菌圖鑑. 臺北市遠流。