Environmental isolation of *Scedosporium* species from the greater Sydney region: a link to the emergence of infections in Australia?

*Scedosporium* species are emerging fungal pathogens in Australia and elsewhere. The reason for this increase in infections is unclear. Since it is assumed that the infections are caused by inhalation of fungal spores, we sampled the urban and rural environment of the greater Sydney region for the presence of the human pathogenic species. Our findings indicate that there may be species-specific associations with areas of high human activity, hinting of a possible link between the environment and the emergence of infections.

Species of the genus *Scedosporium* are emerging fungal pathogens that cause a wide range of clinical disease, from superficial skin/soft tissue infections to disseminated infections. Until recently, *S. prolificans* and *S. apiospermum* (asexual state of the species *Pseudallescheria boydii*) were the only clinically important species in this genus. *S. apiospermum/P. boydii* has a worldwide distribution, whereas *S. prolificans* is most prevalent in Spain, Australia and the United States.

Recent phylogenetic analysis showed that *S. apiospermum/P. boydii* is a complex of species, which is now known to consist of at least seven different species. These studies also demonstrated that *P. boydii* and *S. apiospermum* are two separate species. Currently, the following species have been accepted: *Pseudallescheria angusta, P. boydii sensu stricto, Pseudallescheria desertorum, Pseudallescheria ellipsoidea, Pseudallescheria fusoidea, Pseudallescheria minutispora, S. apiospermum, Scedosporium aurantiacum* and *Scedosporium deboogii*.

Of these species, *P. boydii*, *S. apiospermum* and the recently described species *S. aurantiacum*, have been recovered in clinical specimens. Both species affect immunocompromised and immunocompetent individuals and as such are not only fungal opportunists but are primary pathogens. Predisposing factors include organ transplantation and malignancy, and also encompass chronic lung disease and diabetes mellitus [Heath et al. unpublished data]. In addition, these organisms are capable of long-term colonisation of the respiratory tract of patients with compromised airways, including those with cystic fibrosis.

Infections caused by *Scedosporium* species, particularly *S. prolificans*, are associated with mortality rates of up to 75-80%. Therefore, early diagnosis and prompt effective antifungal treatment is mandatory to improve patient outcomes. Given that treatment is problematic as these pathogens are inherently less susceptible or resistant to currently available antifungal agents, a better understanding of the epidemiology, mode of transmission and ecological niche of *Scedosporium* spp. is important for the implementation of alternative pre-emptive and preventive strategies.

The importance of scedosporiosis in Australia has been highlighted by recent reports, which describe the epidemiology and clinical
features as well as outcomes of infection. A single-centre study including 59 patients highlighted the emergence of *Scedosporium* spp. as causative agents of human mycoses. In a large Australia-wide population-based study involving 180 occasions of isolations, distinct risk factors for invasive disease and clinical features of *Scedosporium* infection were analysed. A key finding of this survey was the identification of a substantial number of the new species *S. aurantiacum* and its ability to cause a wide range of invasive infections [Heath et al. unpublished data].

The emergence of *Scedosporium* infections also has public health significance. In this regard, understanding of factors that have contributed to their emergence would assist in implementing appropriate early intervention strategies. Given that *Scedosporium* spp. are ubiquitous in nature, and that infection is thought to be acquired via inhalation of airborne fungal spores, it is logical to postulate that exposure to these organisms in the environment may have contributed to the increase in human infections. Thus far, a limited number of studies have indicated that the main ecological niche of the *P. boydii* complex include environments heavily exploited by agricultural activities or human impacted environments such as cities and industrial areas. However, the association between the occurrence of *Scedosporium* spp. in the environment and the prevalence of scedosporiosis remains uncertain and the ecological niche of *S. prolificans* and *S. aurantiacum* are poorly defined.

As the first step towards finding such an association, a preliminary survey was undertaken to study the occurrence of *Scedosporium* spp. in the environment, specifically from the soil in the urban, high-populated areas in the greater Sydney region. In this

![Figure 1. Environmental sampling sites in the greater Sydney region indicating the number of isolates recovered from soil and the percentage of isolates belonging to either *S. aurantiacum*, *S. dehoogii*, *S. prolificans* or *P. boydii*.](image)

**Figure 1.** Environmental sampling sites in the greater Sydney region indicating the number of isolates recovered from soil and the percentage of isolates belonging to either *S. aurantiacum*, *S. dehoogii*, *S. prolificans* or *P. boydii*.**
survey, two soil samples were each taken from a number of randomly selected locations around urban areas in the greater Sydney region (Figure 1). For comparison, sites in suburban and rural areas around Sydney were also sampled. Ten sites were sampled in the Blue Mountains National Park, which were subsequently treated as a single site because of the low numbers of isolates recovered form those sites. The samples were collected from the superficial soil layers, transferred into

Figure 2. Species identification.
(2a) primary isolation plate (selective medium: Dichloran Rose-Bengal chloramphenicol agar supplemented with benomyl); (2b) *S. prolificans* macro colony morphology on PDA; (2c) *S. prolificans* micro-morphology; (2d-I) *S. aurantiacum* macro colony morphology on PDA; (2d-II) *S. aurantiacum* reverse site macro colony morphology on PDA, showing yellow diffusible pigment; (2e) *S. aurantiacum* micro-morphology; (2f) *P. boydii* macro colony morphology on PDA; (2g) *P. boydii* micro-morphology with ascoma and ascospores; (2h) *S. dehoogii* macro colony morphology on PDA; (2i) *S. dehoogii* micro-morphology; (2j) Examples of RFLP patterns obtained after double digestion of the ITS1/2 region of the rDNA gene cluster with the enzymes *Sau*96I and *Hha*I.

M=1kb plus molecular weight marker (Invitrogen, USA), lanes 1 till 9 environmental samples obtained from Darling Harbour, Lane 1 = WM09.12 (*S. aurantiacum*), Lane 2 = WM09.30 (*S. prolificans*), Lane 3 = WM09.31 (*S. prolificans*), Lane 4 = WM09.32 (*S. prolificans*), Lane 5 = WM09.13 (*S. aurantiacum*), Lane 6 = WM09.14 (*S. aurantiacum*), Lane 7 = WM09.15 (*S. aurantiacum*), Lane 8 = WM09.16 (*S. aurantiacum*), Lane 9 = WM09.17 (*S. aurantiacum*), Lanes 10 till 12 standard strains, Lane 10 = WM06.482 (*S. aurantiacum*), Lane 11 = WM06.472 (*S. apiospermum*), Lane 12 = WM06.525 (*S. prolificans*).
sterilised containers and processed as previously described. In short, 1g of soil was suspended in 10ml sterile water, and 2ml were cultured on the selective medium Dichloran Rose-Bengal chloramphenicol agar [Oxoid, United Kingdom] supplemented with benomyl at a concentration of 10µg/ml agar [Sigma-Aldrich, USA]. The plates were incubated at 35°C, and were regularly examined for growth of fungi with typical Scedosporium colony morphology. Colonies suspicious for Scedosporium spp. were isolated, cultured on Potato Dextrose Agar (PDA) [Oxoid, United Kingdom], and species identification was performed by routine morphological as well as by molecular methods (Figure 2), using restriction fragment length polymorphism analysis. The identification of isolates with a presumptive morphological identification as S. deboorgii or P. boydii were confirmed via ITS sequence analysis.

Results of this preliminary survey showed that Scedosporium spp. can be isolated from most of the collection sites (Figure 1). A total of 64 Scedosporium isolates were recovered, of which 38 were identified as S. prolificans, 21 as S. aurantiacum, four as P. boydii and one as S. deboorgii. Soil samples from the urban areas showed a relatively higher density of organism per gram of soil compared to rural areas (Figure 1). S. aurantiacum was recovered from urban areas with high human activities, but not from areas with a low human population density (Figure 1). S. prolificans was found in both rural and urban areas, but in much higher density in urban areas (Figure 1).

The results of the survey found the occurrence of Scedosporium spp. in the soil of urban areas in the greater Sydney region to be common. This raises the possibility that increased exposure to (as yet unidentified) environmental sources may place individuals at risk for developing a condition.

To verify the proposed link between the environmental occurrence and clinical infection, molecular typing studies, using PCR-fingerprinting and multi-locus sequence analysis, comparing the genotypes of environmental isolates with those of clinical isolates are under way. The data generated in this environmental survey has the potential to be used to trace the route of infection and to determine and monitor high-risk environmental areas.

References