Appendix 2: Fungi Sub-group Report

Status, Trends and Recommendations on Fungal Diversity

Overview of Status and Trends

The Kingdom *Fungi* is the second most speciose eukaryotic kingdom, encompassing an enormous diversity of taxa with varied ecologies, life cycle strategies, and morphologies ranging from unicellular aquatic chytrids to large mushrooms (Tang et al., 2007; Blackwell, 2011; Mora et al., 2011). In different ecosystems, fungi make conditions suitable for the evolution and existence of macroscopic life forms and continue to drive and profoundly influence many of the essential biogeochemical cycles (Staley, 1997). The most widely cited global estimate of 1.5 million by Hawksworth (1991) has been considered to be an underestimate because numerous potential fungal habitats and localities remain understudied (Hawksworth, 2001). More recent estimates based on high-throughput sequencing methods and extrapolations suggest that the global diversity may be anything from 3.5 to 5.1 million species (O'Brien et al., 2005; Blackwell, 2011; Mora et al., 2011; Hawksworth, 2012). Yet, only about 100,000 species have so far been described (Kirk et al., 2008).

Compared with vascular plants and many groups of animals, the consideration of fungal conservation is generally lagging behind. National Red List assessments of fungi have been conducted in at least 35 countries (33 European countries, Japan and New Zealand), resulting in nearly 7000 macrofungal species being nationally red listed (Dahlberg et al. 2010). Other ecologically distinctive microfungal species (e.g. host specific obligate pathogens) have also been included in some countries' fungal conservation assessments. European mycologists have been preparing a list of fungi for possible inclusion through the European Council for Conservation of Fungi (ECCF, www.wsl.ch/eccf/) since 1991. However, in the IUCN Red List version 2014:2, only one macrofungus (*Pleurotus nebrodensis*) and two lichenized fungi (*Cladonia perforata* and *Erioderma pedicellatum*) are included in a total of 74106 animal, plant, fungal and protist species globally red-listed (IUCN, 2014).

There are many reasons to produce fungal Red Lists as pointed out by Dahlberg and Mueller (2011). Firstly, management and conservation of species and ecosystems do not operate in isolation, but rather in a world with multiple, disparate and often opposing interests operating over varying time perspectives. Thus, the better documented the status and trends are, the more likely decision-makers and the public will consider the issue and take action. Secondly, Red Lists communicate the presence and value of fungi to politicians, decision-makers and other stakeholders including the public at large. Thirdly, Red List evaluations identify key gaps in our knowledge of fungal biology and diversity. Such gaps include taxonomic problems, distribution and autecological requirements, difficulty of identifying and defining individuals, and challenges of determining the drivers and constraints on population dynamics. Fourthly, omission of fungi in Red Lists invites the mistaken conclusion from conservation agencies that fungi are not threatened.

Nevertheless, some difficulties in consideration of fungal conservation include the perception by some mycologists and other scientists that species of fungi are intractable to rigorous assessment of their conservation status due to their unique biology, predominantly cryptic life forms and paucity of taxonomic, distribution and ecological data. The strong fluctuation in annual fruiting due to differing weather conditions and irregular fruiting patterns of some species and individuals, and the low correlation between the presence of sporocarps and the presence and extent of mycelia (e.g. Straatsma et al., 2001 and Mueller et al., 2004) are additional issues that need to be considered when assessing changes in population size of fungal species. Mycologists have often had difficulties in applying the IUCN criteria for fungi, particularly for the concepts of mature individual, generation length, location, fragmented distribution and how uncertainty and absence of data should be handled (Hallingbäck, 2007 and Heilmann-Clausen and Vesterholt, 2008). This has resulted in the use of varying interpretations in different countries rendering it difficult to compare these lists among countries or to Red Lists of other groups of organisms.

What is the current status of fungi in Hong Kong? The only checklist of Hong Kong fungi, which was published by Hyde et al. (2000), reported that 2122 fungi were recorded locally. This included 757 anamorphic ascomycetes, 419 ascomycetes, 479 basidiomycetes, 390 lichens, 60 myxomycetes, 14 oomycetes and 3 zygomycetes. However, this figure is apparently outdated and should be re-visited critically. Hong Kong is located in the sub-tropics and it is expected that species diversity is much higher than in any temperate regions (Hillebrand, 2004; Tang et al., 2007). Then, how many species are there in Hong Kong? This is a difficult question since fungal numbers are recently suggested to outnumber land plants by as much as 10.6:1 (O'Brien et al., 2005) or 3.5:1 for macrofungi alone (Cifuentes Blanco et al., 1997).

Major Threats

a) **Forest degradation or destruction** by human activities, urban development or hill fires: many mycorrhizal fungi and at least some wood-inhabiting fungi are host-specific and dependent on particular plant species for survival. Habitat degradation and destruction may make it difficult for some species to maintain normal population.

b) **Indirect effects of climate change**: modification of vegetation and habitat environment may exert indirect pressure on climate-sensitive species and many host-specific species. Such changes might favour the development of more plant pathogenic fungi as alien competitors against native mycorrhizal fungi. Grassland macrofungi may also be affected. Although there was no study or data on this aspect locally, a long-term monitoring in Dinghushan Nature Reserve indicated there are some effects of climate change on the structure and phenological pattern of mushrooms in protected forest (restricted areas without human disturbance) (pers. comm. Prof. Li Tai Hui, Guangdong Institute of Microbiology).

Major Knowledge Gaps to be Filled

a) There is no updated **list of macrofungi** in Hong Kong and it is difficult to identify species with special scientific interest and compare with the diversity of fungi of nearby forests in South China.

b) Knowledge of the basic **ecology of macrofungi** in Hong Kong (mycorrhizal, parasitic and saprotrophic fungi) is very poor: very simple data about phenological patterns, distribution and abundance are missing for the vast majority of species. For example, there is no data regarding the phenology, distribution and abundance of the most important poisonous mushroom genus (also ecologically interesting) Amanita (mycorrhizal fungi).

c) **Ecto-mycorrhizal fungi** association with *Eucalyptus*, *Castanopsis*, *Machilus*, *Lithocarpus*, Orchids (especially the rare species) in Hong Kong are generally unknown or unclear. Russulales and Boletales have very limited hosts and their conservation status has always been a good subject to review. Monitoring studies should be conducted with a few genera to see if any species are declining within the habitat. A few species may be selected as indicator species of habitat quality (this is widely applied in Europe).

d) Little is known of population densities of **wood decay fungi** (parasitic and saprotrophic fungi) in secondary forests and urban plantations. Wood decay fungi are associated with naturally short-lived resources that are spatially restricted. With the change of forest and urban plantation, there may be change in availability of certain types of dead woods, resulted in a decline in some saprotrophic species. On the other hand, some facultative parasites may develop exceptional dispersal ability and become particularly virulent in plantation trees (e.g. *Phellinus noxius* on *Ficus* spp.).

Recommendation

a) Funding for conducting survey on macrofungal diversity is necessary. Comprehensive survey is recommended to start in Tai Po Kau Nature Reserve and any fung shui woods (e.g. Mui Tsz Lam). It would be the first step in answering many fundamental questions, such as fungal-plant associations, species diversity, phenology, and hence how well the ecosystem is functioning now, such as the proportion of pathogenic, mycorrhizal and saprotrophic fungi within the site.

b) Mycorrhizal fungi such as *Boletus*, *Russula* or *Lactarius* are recommended to be the priority genera for study. These genera have tight plant-fungus association, sensitive to disturbance and could become potential candidates for indicator species of forest quality. After such study, flagship species may be identified for fungal conservation.

Reference:

Blackwell, M. 2011. The fungi: 1,2,3. 5.1 million species? *American Journal of Botany* 98: 426-438.

Cifuentes Blanco, J., Villegas Ríos, M., Villarruel-Ordaz, J. L. & Sierra Galván, S. (1997) Diversity of macromycetes in pine-oak forests in the neovolcanic axis, Mexico. In Mycology in Sustainable Development: expanding concepts, vanishing borders (M. E. Palm & I. H. Chapela, eds): 111-121. ParkwayPublishers, Boone, NC.

Dahlberg, A., Mueller, G.M. 2011. Applying IUCN Red Listing Criteria for assessing and reporting on the conservation status of fungal species. Fungal Ecology 4: 147-162.

Dahlberg, A., Genney, D.R., Heilmann-Clausen, J. 2010. Developing a comprehensive strategy for fungal conservation in Europe: current status and future needs. *Fungal Ecology* 3: 50–64

Hawksworth, D.L. 1991. The fungal dimension of biodiversity: magnitude, significance, and conservation. *Mycological Research* 95: 641-655.

Hawksworth, D.L. 2012. Global species numbers of fungi: are tropical studies and molecular approaches contributing to a more robust estimate? *Biodiversity Conservation* 21: 2425-2433.

Hillebrand, H. 2004. On the generality of the latitudinal diversity gradient. *American Naturalist* 163: 192-211.

Kirk, P.M., Cannon, P.F., Minter, D.W., Stalpers, J.A. 2008. *Ainsworth & Bisby's Dictionary of Fungi*, 10^{th} edn. CAB International, Wallingford.

O'Brien, B.L. , Parrent, J.L., Jackson, J.-A., Moncalvo, J.-M., Vilgalys, R. 2005. Fungal community analysis by large-scale sequencing of environmental samples. *Applied and Environmental Microbiology* 71: 5544 – 5550.

Tang, A.M.C., Shenoy, B.D., Hyde, K.D. 2007. Fungal Diversity. In: Reconstructing the Tree of Life: Taxonomy and Systematics of Species Rich Taxa. Hodkinson, T.R., Parnell, J. (Eds.), Systematics Association Series, CRC Press, London, U.K.

Prepared by Alvin Tang