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Fruiting patterns of macrofungi in tropical and temperate land use types in Yunnan Province, China

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ABSTRACT

Despite the important contribution of fungi to forest health, biomass turnover and carbon cycling, little is known about the factors that influence fungal phenology. Therefore, in order to further our understanding on how macrofungal fruiting patterns change along a gradient from temperate to tropical climate zones, we investigated the phenological patterns of macrofungal fruiting at five sites along a combined altitudinal and latitudinal gradient in SW China and NW Laos, ranging from temperate to tropical climates. Observations were conducted in the dominant land use types at these study sites: mixed forest (all sites), coniferous forest (temperate sites) and grassland (temperate sites). In total, 2866 specimens were collected, belonging to 791 morpho species, 162 genera, and 71 families. At the site level, the fruiting of ectomycorrhizal (EcMF) and saprotrophic fungi (SapF) occurred at the same time among all land use types. The fruiting season of fungi in the tropical sites began earlier and ended later compared to that of fungi in the temperate sites, which we attribute mainly to the higher temperature and more abundant rainfall of the tropical areas. EcMF taxa richness in temperate forests (both coniferous and mixed forest) showed a distinct peak at the end of the rainy season in August and September, while no significant peak was observed for SapF taxa richness. Neither functional fungal groups showed significant seasonal fluctuations in tropical areas. The temporal turnover of fungal fruiting significantly increased with the shift from tropical to temperate forests along the elevation gradient. In the grasslands, macrofungal abundance was less than 22% of that of corresponding forest sites, and taxa richness was 42% of that of corresponding forest sites. Fungal fruiting showed no significant fluctuations across the rainy season. This work represents a case study carried out over one year, and further measurements will be needed to test if these results hold true in the longer term.

1. Introduction

Macrofungi play an essential role in ecosystems (Morris and Robertson, 2005), and are mainly comprised of saprotrophic and mycorrhizal fungi according to their life strategy and ecological function (Lin et al., 2004; Tedersoo et al., 2010). Saprotrophic fungi decompose organic matter, thus influencing nutrient cycling in ecosystems (Moore et al., 2004), while mycorrhizal fungi form symbiotic relationships with plants, significantly improving plant growth, nutrition, and stress resistance (Courty et al., 2010; Gehring et al., 2014; Martín-Pinto et al., 2006), thus affecting the development and stability of plant communities (Kernaghan, 2005; Westover and Bever, 2001). Most mycorrhizal macrofungi are ectomycorrhizal (Tedersoo et al., 2010). Apart from their ecological functions, edible macrofungi generate large economic value in many areas across the world, with a distinct seasonality in mushroom fruiting time. Wild edible macrofungi are one of the most important types of non-timber forest product (NTFP) in the Great Mekong River Subregions and play an important role in contributing to the

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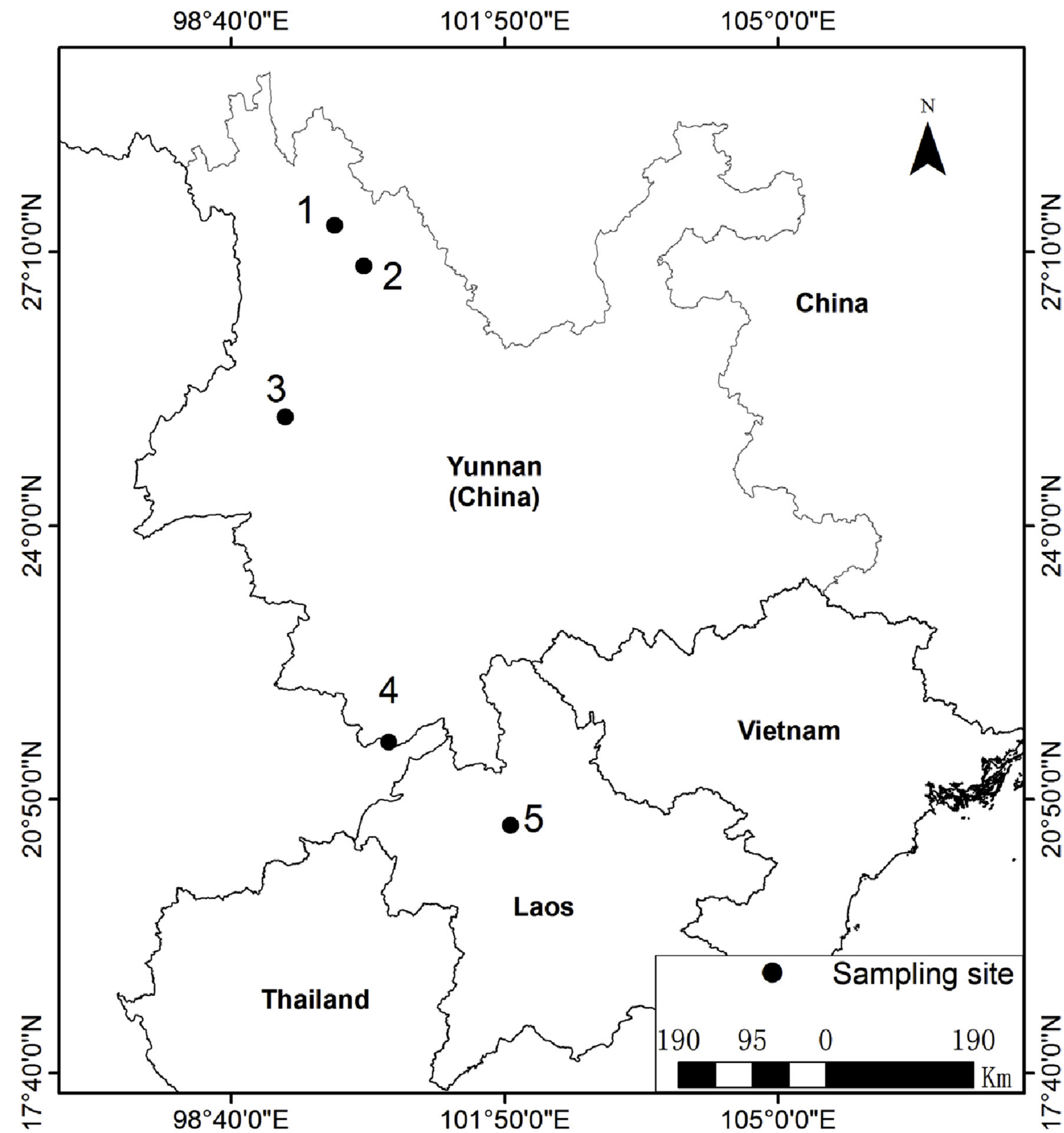

Fig. 1. Map of the sampling sites that were selected along an altitudinal and latitudinal gradient spanning from temperate to tropical climates. 1 Shangri-La, 2 Lijiang, 3 Baoshan, 4 Mengsong, 5 Oudomxay.

household income of mountainous communities in this area (McLellan and Brown, 2017; Yang et al., 2008). China's Yunnan province is well-known for its fungal diversity: nearly 44% of global wild edible fungi species currently known to science can be found in this southwestern province, and the gross output of China's wild edible fungi can reach up to 2 billion Yuan (Yu et al., 2002). However, economic development in Yunnan has led to the destruction of forests and decreases in macro-fungal production (Hua et al., 2017). In an effort to provide information which could be used to optimize wild mushroom harvests. It is essential to increase our knowledge about mushroom fruiting times in order to help forest managers and mushroom pickers plan and carry out the sustainable collection of edible macrofungi.

The timing of phenological events has ecological consequences due to effects on species' interactions and demography (Diez et al., 2012; Encinas-Viso et al., 2012), and ecosystem functions (Richardson et al., 2010). Because a broad variety of phenological events have been shown to change over time and in response to climatic trends, phenology has been used as an early indicator of climate change (Menzel et al., 2006). However, the vast majority of studies of changes in phenology have been conducted on animals and plants, whilst phenological studies of the fungal kingdom have only recently been initiated (Büntgen et al., 2012, 2013). Changes in macrofungal phenology due to climate change have been observed in both Europe and Asia (Gange et al., 2011; Kauserud et al., 2008; Yang et al., 2012). Although Asia exhibits high levels of macrofungal diversity, few studies have investigated the phenology of macrofungi in this region (Sato et al., 2012). Past work by Parmesan (2007) has shown that temperature and rainfall are key determinants of macrofungal phenology.

Previous studies which researched the fruiting patterns of ectomycorrhizal fungi in subtropical and temperate forests showed different fruiting patterns (unimodal or bimodal, respectively) in these climatic areas (Christensen, 2010; Kranabetter and Kroeger, 2001; Matsuda and Hijii, 1998). Kauserud et al. (2008) found a geographic difference in fruiting time between Northern and Southern Norway, with earlier fruiting in northern continental areas compared to southern oceanic areas. Some studies looked at both ectomycorrhizal fungi and