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光照条件、植株冠层结构和枝条寿命的关系——以桂花和水杉为例

Relationships among light conditions, crown structure and branch longevity: a case study in *Osmanthus fragrans* and *Metasequoia glyptostroboides*

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中文摘要:

根据衰老理论的代谢率假说,生物寿命与其代谢率有关,个体大小相同的生物体,在质量较好的微生境中通常比较差生境中具有更高的代谢速率。因此,生物体在资源供给较差的生境中通常比资源供给较充足的生境中具有更长的寿命。枝条是木本植物植冠构建的基本单元之一,如果枝条遵循代谢率假说,则可推测在光照较好环境下的植物枝条或小枝将比其在遮荫环境下具有更短的寿命,即枝条寿命与光照条件成反比。以常绿物种桂花(*Osmanthus fragrans*)和落叶物种水杉(*Metasequoia glyptostroboides*)为研究对象,通过测量不同光照环境下,植株大小(株高和胸径)、冠层深度、冠层轮廓(冠层深度/冠层宽度)、相对冠层宽度(冠层宽度/植株高度)以及植株凋落枝条寿命等性状,探讨了光照条件对成年植株冠层形态结构和植株枝条寿命的影响。调查发现:1)枝条的寿命在遮荫条件下显著高于全光照条件下,与理论预测吻合;2)随遮荫程度增加,植株冠层深度和冠层轮廓增加,相对冠层宽度减小;3)枝条的平均寿命与植株冠层深度和冠层轮廓成正比,与植株相对冠层宽度成反比。这表明光照条件可能通过改变植株冠层结构来影响枝条寿命。未来需要进一步研究枝条生物量分配、叶片光合能力和呼吸速率在不同生活型物种之间的差异,以便更全面的理解枝条寿命与生境质量之间的关系。

English Summary:

According to the rate of living theory of aging, the longevity of living organisms should be negatively correlated with body metabolic rate. For the organisms having the same body size, the metabolic rate is usually greater in favorable habitats than in poor-quality sites, as demonstrated in many previous studies. Therefore, it is expected that organisms would live longer in environments with low-resource availability than in their counterparts. Specifically, we hypothesize that plant branches or twigs would live shorter in sun-lit microhabitats than in shaded or partial-shaded ones. This hypothesis is consistent with the recently established leaf and wood economic spectrums, in which leaf longevity is positively associated with leaf mass per area but negatively with leaf nitrogen content and photosynthetic capacity that often characterize favorable sites. A similar hypothesis has also been interspecifically tested to be true at whole-individual level of tree species, where long-lived species are often associated with low respiration rates.
In order to test the above hypothesis, we in this study examined the effects of light level on branch longevity and on the relationship between crown shape and the longevity for an evergreen species (*Osmanthus fragrans*) and a deciduous species (*Metasequoia glyptostroboides*) in Nanjing, southeast China. We measured plant size (height and diameter at breast height), crown depth (i.e. vertical crown length) that was obtained by plant height minus under branch height, crown profile that was calculated as the ratio of crown depth to crown width, and relative crown width that was defined as the ratio of crown width to plant height; we also determined the longevity of shed branches by bud scales for plants (with similar size) grown in different light conditions (under full sun light/unshaded, partial shaded, fully shaded).
In both species, branch longevity was found to be significantly greater for plants living in the fully-shaded environments than for those grown in open sites; the longevity increased with increasing shading level, consistent with the theoretical prediction. Crown depth and crown profile increased, but relative crown width decreased with increasing shading level in both species, i.e. shading tended to result in narrow and deep plant crowns. In addition, branch longevity was positively correlated with crown depth and crown profile but negatively with relative crown width in both species, and branch longevity was positively related to relative crown depth in *O. fragrans*, not in *M. glyptostroboides*. The possible underlying mechanism is that shading might have increased the level of apical dominance but decreased the self-shading level of crown interior (as reflected by increased crown profile and decreased crown width), which potentially led to low metabolic rates.
These results collectively suggest that the morphological responses of plant crowns to light may largely account for the variation in branch longevity under different shading levels. However, the current study did not address the importance of life form to plant metabolic rates and organism longevity despite two different species being investigated. Future studies need to examine branch biomass allocation, leaf photosynthetic capacity and respiration rates to fully understand the relationship between branch longevity and habitat quality for species differing in life forms.

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