夏季干旱期新老毛竹水分传输和水分竞争研究

方东明

（浙江农林大学暨阳学院 诸暨 311800）

摘　要：【目的】毛竹(*Phyllostachys heterocycla*) 作为一种分布广泛的高大散生木本竹种,具有重要的生态和经济价值。近年来夏季极端高温干旱事件频发，常导致当年生毛竹大量死亡，为毛竹林生产力恢复和灾后演替埋下重大隐患。为深入理解毛竹在新老龄级上的死亡差异机理，本研究聚焦于两个主要研究内容：1）夏季极端干旱进程中毛竹新老竹的水分利用和水力性状响应差异；2）以及新老竹因生理整合而对竹鞭系统的水分共享与竞争。【方法】在 2020 年夏季 7-9 月，通过林下接近 100%截雨处理实现夏季干旱。在实验前，为提高热消散探针（TDP）的测量准确性，对 TDP 进行了不同年龄毛竹的室内校正。实验期间，使用 TDP 连续监测竹鞭相连的新老竹茎秆和竹鞭液流，并定期测量叶片光响应曲线和茎秆、枝条和叶片导水损失率。【结果】研究结果表明：（1）TDP 在不同年龄竹秆上构建的经验公式有显著差异，野外观测之前需要建立因年龄而异的校正公式。（2）基于 TDP 对毛竹液流的观测，野外干旱处理下新竹茎秆液流高于老竹，且新竹始终保持显著高于老竹的蒸腾作用；但总体上，干旱持续时长和强度的增加显著降低了新老竹的耗水。（3）光合有效辐射和土壤湿度是毛竹液流的两个主要限制因子。干旱使老竹液流的限制因子发生了改变，从光合有效辐射变为土壤湿度。但是新竹液流的限制因子始终是土壤湿度。同时土壤湿度也是干旱下毛竹生理指标的主要限制因子，它显著降低了新老竹的光合能力且增大了导水损失率。（4）在干旱环境下，竹鞭为对新竹维持蒸腾需求提供了水分支持，并通过夜间液流对毛竹茎秆储存水进行补充，但这一机制缓解干旱的能力有限。【结论】综合结果表明，新竹在干旱环境下虽然拥有强于老竹的水分竞争能力，但高蒸腾需求特点使其在干旱下水力结构更容易受到损伤。持续的干旱致使新竹木质部栓塞无法及时恢复，最终引发水力失效可能是导致其更早遭受死亡的原因。本研究将为经营和管理气候变化下的竹林提供水分生理生态上的理论支持。

关键词：毛竹；高温干旱；液流；生理整合；水分利用策略

Abstract: 【Objective】As a giant woody bamboo species distributing widely, Moso bamboo (*Phyllostachys edulis*) has high ecological and economic values to the local communities. Extreme events with high temperature and intensive drought occurred frequently in recent years, which had led to significantly higher mortality rate of newly sprouted culms, posing a threat to the post-disaster recovery and succession of Moso bamboo forests. To deeply understand the mechanism of differential age-specific drought-induced mortalities on Moso bamboos, This study focused on exploring the age-specific water-use and hydraulic response of newly sprouted and established culms, and the water share and competition via physiological integration of rhizomes between the newly sprouted and established culms. 【Method】During summer (July to September) in 2020, we conducted a drought treatment by setting up a manipulated throughfall exclusion plot within a bamboo forest of approximately 10 ha in Lin'an city

(30°14′N,119°42′E), Zhejiang Province, China. To improve the measurement accuracy of Thermal Dissipation Probe (TDP), we calibrated the original empirical formulas for Moso bamboo with different ages in laboratory before applying TDP. In the field we have continuously monitored the environmental factors and sap flow rates in newly sprouted and established culms and rhizomes between them, and periodically measured the light response curves of leaves and the percentage loss of xylem conductivity of culms, branches and leaves.【Result】The results showed that: (1) There are significant differences on the empirical formulas of TDP on bamboo culms with different ages, and it is necessary to build age-specific correction for different ages. (2) By applying corrected age-specific TDP formulas, we found that sap flow densities and daily water use of the newly sprouted culms were higher than that of the established culms. But the water consumption of bamboos was significantly reduced with the progressing and intensifying of the summer drought. (3) Radiation and soil moisture were the two main factors limiting sap flow of established culms and newly sprouted culms in the ambient condition. However, drought changed the limiting factors from radiation to soil moisture for established culms, but no change appeared in those newly sprouted culms. At the same time, soil moisture was also the main limiting factor of physiological indexes of Moso bamboos under drought, which significantly decreased photosynthesis and increased percentage loss of conductivity of both newly sprouted and established culms. (4) During drought, the rhizome provided water sources for the transpiration of Moso bamboo and provided water to refill the culms through nighttime sap flow for the newly sprouted culms, but this support mechanism to alleviate drought is limited.【Conclusion】In summary, compared to established culms, the newly sprouted culms have stronger competition for water in the rhizome system under drought conditions, but their higher transpiration demand led to more susceptible hydraulic structures. Thus, previously observed higher mortality of the newly sprouted bamboos may be attributed the increasing xylem embolism and eventually hydraulic failure that could not recover during a continuous severe drought. This study will provide theoretical support for drought-coping management of Moso bamboo forests under climate change.

Key words: *Phyllostachys edulis*; high temperature and drought; sap flow; physiological integration; Water use strategy