

DNA条形码在进化生态学研究中的应用

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Applications of DNA barcoding in evolutionary ecology

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DNA条形码是最近十几年发展起来的一门生物技术, 具有标准、通用、快捷等优点, 其主要目标是通过较短的DNA序列在物种水平上对现存生物类群和未知生物材料进行识别和鉴定(Hebert *et al.*, 2003; 裴男才和陈步峰, 2013)。目前, 植物DNA条形码已较成熟地应用于群落系统发育(或称谱系)与进化生态学研究, 主要回答两大科学问题:

(1)通过DNA条形码构建群落系统发育关系(Kress *et al.*, 2009; 裴男才等, 2011), 其核心理念是通过具有不同进化速率的DNA条形码片段组合, 相对准确地构建出特定森林群落的系统发育关系大框架, 且在科或者属级分类阶元下的类群能获得比基于APG系统进化树更精准的末端分支。

(2)将基于DNA条形码的群落系统发育关系用于探讨局域、区域乃至全球尺度上森林群落格局的构建方式和维持机制(Kress *et al.*, 2009; Pei *et al.*, 2011; Swenson *et al.*, 2012; Erickson *et al.*, 2014), 其核心理念是通过运用实测的DNA条形码群落系统发育关系, 获取更接近真实的群落系统发育结构和多样性分布格局, 减少发生统计误差的概率。

此外, DNA条形码作为一种非损伤性技术, 可量化动物取食特征和种子传播交互网络, 评估每种食果动物对不同小生境中种子雨的贡献, 还可检测不同食果动物是否选择性地取食不同果实或种子类型, 在植食性特征和种子凋落格局之间构建出沟通的桥梁(González-Varo *et al.*, 2014), 进而构建植食性动物与被取食植物的复杂网络关系, 探讨动植

物协同进化关系(Jurado-Rivera *et al.*, 2009; García-Robledo *et al.*, 2013)。

最近几年, 植物DNA条形码研究在群落水平上获得了一系列进展, 如物种辨别、群落系统发育关系构建、群落结构探索和生物多样性指数评价等, 这主要得益于CTFS-ForestGEO网络(<http://www.forestgeo.si.edu/>)和中国森林生物多样性监测网络(<http://www.cfbiodiv.org/>)等研究平台。当然, 其研究仍然存在一些问题:

(1)各森林群落现有的植物DNA条形码序列数据大多零散分布于各样地, 部分数据尚未得到充分应用。为了有效使用现有数据, 建议各样地自行或授权上传并管理相关数据(如The Barcode of Life Data Systems, <http://www.boldsystems.org/>), 其他用户经过必要审核后可共享相应数据。数据拥有者和使用者之间可以进行实时交流, 实现跨区域数据管理、整合与应用。

(2)疑难类群的准确辨别仍有难度, 常规DNA测序技术及所获得的数据难以满足更多科研任务。对目标类群进行标本鉴定的一个重要发展趋势是基于大量DNA条形码序列的数据库进行初步分子鉴定, 同时与形态、化学、细胞、化石等生物证据相结合(陈文辉等, 2014; Dowton *et al.*, 2014; van Dijk *et al.*, 2014)。但是, 重建群落内各物种起源过程, 探索物种的形成和分化速率, 预测未来演化进程等复杂科学问题, 需要借助更大规模的DNA序列数据库和更强大的分析方法(陈之端和李德铎,

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2013)。转录组、全基因组测序等新一代生物技术能提供更多的遗传信息,有望在对疑难生物类群进行快速、准确识别的基础上(Kane *et al.*, 2012; Li *et al.*, 2015),促进DNA条形码序列信息在生态、进化和生物多样性等方面的充分应用(Guo *et al.*, 2015; Sarwat & Yamdagni, 2015)。

(3)最优植物DNA条形码有待更多的评价。选取合适的DNA条形码对进化生态学研究至关重要。在动物和微生物研究领域,通用DNA条形码的应用和进展相对顺利(前者:线粒体基因细胞色素C氧化酶COI;后者:ITS和18S rDNA) (Hebert *et al.*, 2003; Pawlowski *et al.*, 2012; 张宇和郭良栋, 2012)。在植物界,现有的核心植物DNA条形码是叶绿体片段组合*rbcL* + *matK*,但诸多研究表明,它们只能识别70%左右的常见陆生植物种类甚至更少,特别是在鉴定近缘和其他疑难类群时需要增加*trnH-psbA*和ITS等更多片段才能获得较为理想的分辨效果

(Kress & Erickson, 2007; China Plant BOL Group *et al.*, 2011; Dong *et al.*, 2015; Liu *et al.*, 2015)。因此,今后可能会对陆生植物条形码进行新一轮的评估,权衡DNA条形码在物种水平鉴定的有效性、便捷性、投入产出比等方面,最终遴选出各方较能接受的新方案。

总之,作为一种实用技术,植物DNA条形码在生态、进化和生物多样性保护等多个领域发挥着重要作用(Joly *et al.*, 2014; 裴男才等, 2014; Kress *et al.*, 2015)。当然,在成为适用性更强、方法论更成熟的技术手段之前,植物DNA条形码仍有待完善,其在发展过程中遇到的部分难题可通过学科融合和技术革新逐渐得到解决。

文中引用的参考文献见附录1 (<http://www.biodiversity-science.net/fileup/PDF/w2015-063-1.pdf>)。

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